THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 64 Thursday, January 23, 1941 No. 1275

PUBLISHED WEEKLY

Subscription Terms (Home and Overseas): 21s. per annum.
All Subscriptions are payable in advance.

THE FOUNDRY TRADE JOURNAL
49, Wellington Street, London, W.C.2.

WARTIME ADDRESS
to which all communications should be sent until further notice :—
3, Amersham Road, HIGH WYCOMBE, Bucks.
Telegraphic Address : "Zacatecas, High Wycombe."
Telephone : HIGH WYCOMBE 1792 (3 lines).

OFFICIAL ORGAN OF
The Institute of British Foundrymen
The Institute of Vitreous Enamellers
The Welsh Engineers' and Founders' Association
The Foundry Trades' Equipment and Supplies Association

Institute of British Foundrymen
PRESIDENT : 1940-41
W. B. Lake, J.P., Lake & Elliot, Limited, Braintree, Essex.
LIST OF SECRETARIES—
General Secretary : T. Makemson, Saint John Street Chambers, Deansgate, Manchester, 3. London Office : 49, Wellington Street, London, W.C.2.
Birmingham, Coventry and West Midlands : A. A. Timmins, A.I.C., 21-23, St. Paul's Square, Birmingham, 3.
East Midlands : S. A. Horton, "Three," Mostyn Avenue, Littleover, Derby.
Lancashire : A. Boyes, "Roseville," 7, Kirkstall Road, Davyhulme, Manchester.
London (pro tem.) : H. W. Lockwood, Stewarts and Lloyds, Limited, Winchester House, Old Broad Street, E.C.2.
Middlesbrough (pro tem.) : J. K. Smithson, North-Eastern Iron Refining Company, Limited, Stillington, Stockton-on-Tees.
Newcastle-upon-Tyne : C. Lashly, Sir W. G. Armstrong, Whitworth & Company (Ironfounders), Limited, Close Works, Gateshead.
Scottish : J. Bell, 60, St. Enoch Square, Glasgow.
Sheffield : T. R. Walker, M.A., F.I.C., 11, Broomgrove Crescent, Sheffield, 10.
Wales and Monmouth : J. J. McClelland, 12, Clifton Place, Newport.
West Riding of Yorkshire : S. W. Wise, 110, Pullan Avenue, Eccleshill, Bradford.
South Africa : F. C. Williams, Mutual Building, Corner of Harrison and Commissioner Streets, Johannesburg.

Bristol : A. Hares, Park Crescent, 648, Stapleton Road, Bristol, 5.
Burnley : H. Buckley, Ellsmere, Norfolk Avenue, Burnley, Lancs.
East Anglian : J. L. Francis, 12, Glenhurst Avenue, Colchester Road, Ipswich.
Falkirk : T. R. Goodwin, "Viewfield," Falkirk Road, Bonnybridge, Scotland.
Lincoln : E. R. Walter, M.Sc., The Technical College, Lincoln.

The Institute of Vitreous Enamellers
President : Professor J. H. Andrew, D.Sc., Department of Applied Science, The University, St. George's Square, Sheffield.
Chairman : W. H. Whittle, W. H. Whittle, Limited, Eccles, near Manchester.
Hon. Secretary Dr. G. T. O. Martin, 21-23, St. Paul's Square, Birmingham, 3.

Foundry Trades' Equipment and Supplies Association
President : G. E. France, August's, Limited, Thorn Tree Works, Halifax.
Secretary : K. W. Bridges, Grand Buildings, Trafalgar Square, London, W.C.2.

Welsh Engineers' and Founders' Association
President : W. E. Clement, Morfa Foundry, New Dock, Llanelly.
Secretary : J. D. D. Davis, 9, Royal Metal Exchange, Swansea.

BRITISH CAST IRON RESEARCH ASSOCIATION
The Registered Office and Laboratories of the B.C.I.R.A. are:—
21-23, ST. PAUL'S SQUARE, BIRMINGHAM
Telephone: Colmore 4274-4275 Telegrams: CIRA
The B.C.I.R.A. Scottish Laboratories are :—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone: 332

Contents

	PAGE
Foundry Research in 1940	49
Correspondence	50
Fire-Prevention Service Now Compulsory	50
Random Shots	50
The Production of High-Silicon Acid-Resisting Castings	51
I.B.F.—West Yorkshire Branch Dinner	52
Problems in Foundry Practice	53
Taking Brinell Hardness Test Readings	54
Distribution of Steel	54
Metallography of Inclusions in Cast Irons and Pig-Irons	55
Melting Losses in the Coreless Induction Furnace	59
Strain-Ageing and Yield-Point Characteristics of Low-Carbon Steels	60
Gases in Steel	62
Welding and Flame-Cutting Wrought Iron	62
The Week's News in Brief	64
Raw Material Markets	66

Foundry Research in 1940

The tradition that the tensile properties of an alloy are the desiderata by which technical progress is registered, dies hard. To obtain the best result from an alloy—especially if it be compounded from cheap raw materials, is both desirable and laudable, yet it still seems necessary that the attention of the metallurgist should be drawn to the engineer's outlook. The latter has available lists of materials which are established as yielding well-known and dependable properties. High tensile and compression; heat, chemical and abrasion resisting; efficient cutting, are but a few of the properties covered by well-known materials easily available to him. He requires in addition that most of these properties must be exhibited by some castings as well as by certain wrought materials. For castings, however, no matter what special property be sought, there is a tacit understanding that the material must be sound, and conform to specified dimensional tolerances. This preamble permits of a rough and ready utility-evaluation of recent research work carried out by members of the foundry industry, placing as it does soundness and dimensional accuracy as being the most appreciated by the engineer. This being so, the palm for recent research work must go to Longden, because he has correlated composition and thermal history with moulding methods, thereby contributing information of the type designed to meet the fundamental requirements of the engineer. In the same field, but having in mind the production of high-duty iron, the work of Francis was of outstanding merit. Much excellent work has been turned out by the Battelle Memorial Institute under the inspiring leadership of Dr. H. W. Gillett. The aspect of this most appreciated by industry is the ease with which the results can be applied beneficially in practice. Amongst other noteworthy American researches is that now being prosecuted on the influence of mould materials on alloys, yet though much useful information is disclosed thereby, really fundamental work would no doubt provide a short cut.

The next most important practical phase of foundry research is the provision of high-duty castings whilst utilising materials cheaper than those normally employed for obtaining any specific property. Outstanding in this field is the work recently published by Tucker, who pointed the way to the better utilisation of the relatively cheap chromium alloys. Inoculation by graphite shows some promise of the production of grey iron castings having improved properties, but, so far, the results are a little difficult of assessment. We doubt if it gives better results than the liquid mixing of two straight cast irons of differing compositions as was described by Judson a few years ago, yet its successful outcome would materially reduce mechanical handling. A factor to be remembered by research workers in the field of cast iron is that the property of elongation can best be bestowed upon the metal by malleablisation, and the cost of this process has to be balanced against that to be associated with alloying. Malleable cast iron has deservedly achieved wide recognition as an engineering alloy. It is ever being improved by fundamental research, and that recently published by Schwartz and his colleagues on the influence of hydrogen warrants study by metallurgists working in other fields. We were surprised to read that oxygen in the gaseous form can exist side by side with free hydrogen in malleable iron. We hope that this cannot be confirmed, as it upsets all our previous conceptions of the co-existence of gases in alloys. The original work of Buchanan in this field of gases in alloys has not only received well-merited approbation in the United Kingdom, but has been the subject of commendation by the American technical Press. Considered from no matter what angle this type of research work must necessarily be both slow and expensive. The production of more data may result in the control of the "seasoning" times for castings; the explanation of the phenomenon of "body" in metals; a possible reduction in alloy additions, and the utilisation of cheaper raw materials. On the other hand, the control of gases in metals may involve the installation of expensive ancillary plant only available to the largest and wealthiest concerns.

Of a more academic character, but none the less useful, is the work of Morrogh, carried out at the British Cast Iron Research Association, into the character of the microscopic inclusions in grey and malleable cast iron. Its appearance has materially enhanced the reputation of the Association as a research institute.

Turning to steel castings, the best piece of work—again American—though not truly of a research character, is that by Duma and Brinson on the methods followed by the Navy Yard at Portsmouth, Virginia. It indicates how control can be established in what is virtually a jobbing shop with excellent results. Another Paper of general character has dealt with the acid Bessemer process, and has emphasised (1) how the process has been neglected by the metallurgist, (2) how it is not only independent of the scrap market, but is a potential source of supply to it, and (3) by so doing will relieve pressure where it is most felt.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Heavy Flywheels

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—The article No. XV by "Tramp" on page 28 of your issue of January 9 permits of an alternative and perhaps better method of attack. This is by making the bottom board as

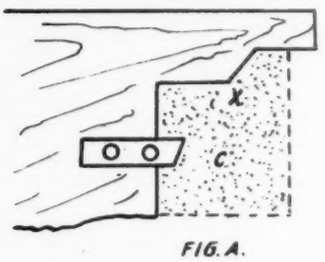


FIG. A.

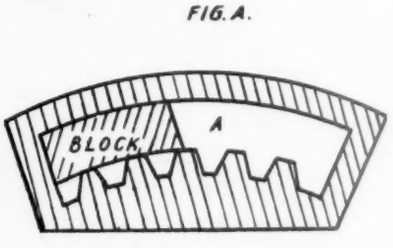


FIG. B.

shown in Fig. A. The seating X is then self centring, and with the aid of four sight holes cut in the joint face the taper can be controlled whilst closing the mould. I would also suggest that the core print C be a loose piece which could be unscrewed and taken from the mould before the remainder of the board.

Fixing the last section of the teeth cores gives some trouble owing to the diametrical dimension of the print back. This is overcome by a loose block placed in the core box (as shown in Fig. B) before ramming. It is then extracted and a thin sheet of cardboard placed on face A, giving the completed core easy assembly in the mould.—Yours, etc.,

A. BUYEN.

23, Niagara Road,
Henley-on-Thames.

Cast Grids

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Referring to "Some Jobbing Foundry Experiences," No. XIV, in your December 19

FIG 1.

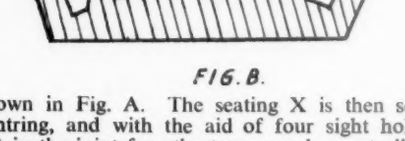


FIG 2

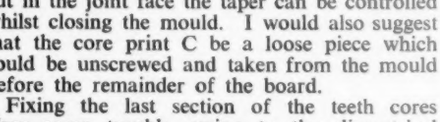
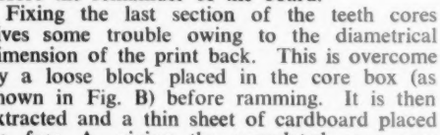


FIG 3.



issue, the following gives an alternative method of overcoming the difficulties to be associated with the making of cast grids.

This method whereby a grid such as is shown in Fig. 1 can be made "open sand" is as follows. A sand bed is made and the top portion of the pattern lightly bedded down so as to form a joint along line A B C (Fig. 2), B C being level. The grid is then marked out and prods inserted where required, as at D, Fig. 3. A thick piece of brown paper E is then placed over the plane A B, and covered with sand. A light weight F placed as in the sketch ensures the top portion G from lifting. This grid can be cast "open sand" or the brown paper can be continued all over the grid and covered with sand, a runner of course being cut through the paper and top sand.—Yours, etc.,

T. E. WAIN.

Brookside, Rolleston,
Burton-on-Trent.

Fire-Prevention Service Now Compulsory

In announcing the Government's compulsory scheme for fire-bomb fighting, the Home Secretary and Minister of Home Security (Mr. Herbert Morrison) explained that by three new Defence Regulations he was taking power to impose compulsory part-time service in all branches of the civil defence force for men and women between the ages of 16 and 60. This power would be used for the time being only in connection with fire-prevention service for countering fire bombs, and the Orders made under the new regulations would be restricted to this form of service and (again for the time being) would apply to men only, within age limits which the Minister would determine.

The compulsory service required is not to exceed 48 hours per month. The Order will apply in all those areas where the risk of fire raids is sufficiently great to require it. Regional Commissioners will be asked to select those local-authority areas in their regions which are the proper ones for the application of the new Order.

All occupiers of factory and office buildings in areas to which the Order applies must make satisfactory arrangements for fire prevention. In particular they must ensure that enough people are available, each with his allotted task. The number required for premises of a given size or character will be indicated in a series of practical guiding rules for fire-fighting in factory and office premises, which will be issued by the various authorities responsible.

There will be a general obligation upon men of all grades, including management, in commercial and industrial premises to take their turn of duty in fire-bomb fighting outside their normal working hours. They will not be entitled to remuneration for this service. But if proper and adequate arrangements to the satisfaction of the responsible authority can be made on a voluntary basis (paid or unpaid), the general obligation need not be enforced. If arrangements, either on a voluntary or compulsory basis, are not made by the occupier, the appropriate authority is empowered to step in and make them, charging the occupier with any expenses involved.

Compulsory service at the place of work takes precedence over compulsory service at the place of residence, but those already doing 48 hours' civil defence service a month in their residential area are not liable to be called upon for duty at their place of work. Compulsion will not apply to members of the Army, Home Guard or police.

The directions to an occupier will come from the appropriate authority. The Admiralty and the Ministries of Supply and Aircraft Production will be responsible for the war factories, and the Ministry of Labour for the general body of factories employing more than 30, and the local authority for factories employing fewer than 30 and for commercial premises. In mixed areas, the appropriate authorities can agree to a transfer of responsibility, so as to have one authority in charge of a single limited area.

In the case of the small factories, the local authority can require premises to combine if their numbers are too small for them to have an effective independent fire-prevention organisation. If necessary, a separate or combined organisation may be reinforced by the local authority from its general pool of enrolled personnel.

Random Shots

Often enough, when a progressive modern wishes to install central heating in his new house, the older generation deprecates the suggestion? "Home isn't home without a fire," they say, and clinch their argument with the sentiment: "It's so nice to look at." This fire-watching business seems ever to have been an Englishman's hobby (King Alfred did a bit), and now the opportunity has come for him to indulge in it to his heart's content. After a term of compulsion, one imagines that fires will no longer be "so nice to look at," and "Marksman" can foresee a sudden boom in the radiator business after the war. (More work for the core-oil makers—hurrah!)

* * *

The natural sequence to fire-watching is fire-fighting, and for that sand is needed. So much of it has suddenly appeared around the lamp-posts and street corners that if the German airmen could only see it all, they would, like the Walrus and the Carpenter, "weep like anything to see such quantities of sand." And Englishmen, after the war, will be saying, also with the Walrus and the Carpenter: "If seven maids with seven mops swept it for half a year, do you suppose . . . that they could get it clear?"

* * *

"Marksman" bought some of that commodity the other day for his own household, and his sand-punching friends may like to know that a bag of 28 lbs. cost a shilling—a price which his wife thought quite reasonable, but which would make a foundryman's hair stand on end! Imagine indifferent sand for foundry use at £4 a ton!

* * *

"The advance of knowledge (of lighting), both scientific and practical, during the last 25 years has been astonishing," reads a report on industrial lighting. More astonishing still is the way in which all Europe is feverishly engaged in blacking-out that 25 years of progress!

* * *

A new postage stamp is soon to be issued in Germany bearing the heads of Hitler and Mussolini. Surely the Duce's final mistake, for no sooner will he appear on a stamp than he will be cancelled out, or, as the French more aptly put it, *oblitéré*.

* * *

Talking of stamps, "Marksman" gathers that collectors are having a thin time just now, with practically no foreign stamps coming into the office! The collector who is on clover at the moment is that extraordinary individual who specialises in matchboxes. The latest curiosity to come into "Marksman's" possession is one from Thailand.

* * *

Everyone is familiar with the stories which are told against absent-minded professors, but what of the absent-minded policeman who went into the grocer's and asked for a pound of traffic jam?

"MARKSMAN."

Non-Spark Sand-Blast Hose

To remove any danger of explosions, fires or other hazards that might be caused by static electricity generated by friction inside or outside the hose in sand-blasting, the Manhattan Rubber Manufacturing Division, Passaic, N.J., developed the Condor sand-blast hose. The specially compounded rubber of the non-spark inner tube and of the cover is said to prevent the development of static electricity. It is also claimed that the extra-heavy tube resists the cutting action of sand and steel shot at high pressures. Over the tube are wrapped four piles of heavy duck, covered with abrasion-resisting black rubber.—"The Iron Age."

The Production of High-Silicon Acid-Resisting Castings

By FRANK MARSDEN (Managing Director, Joseph Stubbs, Limited)

It is generally known to the chemical industry that an alloy having the following analysis is very high in acid-resisting quality:—Silicon, 14.5 to 16; sulphur, 0.004 to 0.02; phosphorus, 0.10 to 0.90; manganese, 0.30 to 0.65; and carbon, 0.10 to 0.80 per cent. Whilst the metal has very high acid-resisting qualities, it is of a friable nature, and will not stand any direct blow or shock. Its performance also against thermal shock is somewhat variable.

It is universally understood by the foundry trade that the successful manufacture of castings to this analysis is both a very hazardous and skilled operation. The methods followed are in many cases totally different from those usually adopted in iron, steel and non-ferrous metal founding. Whilst much of the following matter might be thought to be unorthodox, practice has proved beyond doubt, so far as the manufacture of this material is concerned, that the methods described are the most successful.

Melting

The metal can be melted in any of the following types of furnace:—Electric, oil or pulverised fuel fired rotary furnaces, Siemens-Martin, crucible or cupola. Continental practice has favoured the use of the rotary or the Siemens-Martin furnace, whilst American practice has relied upon either the electric or the rotary furnace. For various reasons, the practice in this country up to the last few months has been to melt in the cupola and the crucible furnace.

In the writer's opinion, the best method of melting is with an electric furnace; the most economical is with the cupola, and this article will deal with metal so melted. To melt in this manner, ferro-silicon has to be mixed with cast-iron scrap in the proportions of 2 of cast-iron scrap to 1 of 45 per cent. ferro-silicon. The usual charges are 6 cwts. made up of 4 cwts. cast-iron scrap and 2 cwts. of 45 per cent. ferro-silicon, plus 10 lbs. of fluorspar or limestone.

The bed of the cupola is made to the usual height and the mixture charged in a similar manner as used in grey iron melting practice. The melting conditions are similar with the exception that the coke consumption is higher. The material in melting has a tendency to "grow" on the sides of the cupola, and unless the cupola is kept very clean "arching over" is prevalent.

Special attention has to be paid to the construction of the tapping hole. The diameter of the tapping hole at the top should not be more than ¾ in. If these instructions are carried out and the tuyeres are kept clean, silicon iron will be successfully melted.

The metal, when melted, should be tapped out into a ladle and poured into ingots or pigs. When the ingots are broken up, it will be noticed that there is considerable variation in the granular structure, proving that the metal is not thoroughly homogeneous, and until the metal has been melted at least three times it is not safe to use it for castings. This applies to melting in all types of furnaces where the mixing of any quantity of this metal takes place.

Moulding

The majority of work is made by the dry sand method, only very small plain unmachined castings being cast in green sand. All pipes, cylinders, etc., are cast vertically with the runners at the top. All top flanges should have at least a 3-in. header cast on them to ensure clean and solid faces after the header is cut off.

In casting pans, vessels, etc., these are always cast with the base upwards. They are run through a series of pencil runners spread over the face of the casting. Owing to the excessive shrinkage of the metal, it has a tendency to segregate at the centre, especially where the section changes, say where a flange joins the main body of a pipe or vessel, etc. To prevent this segregation occurring, recourse to chilling has to be made. A series of heavy chills placed at the points where the draw takes place will solidify the casting and a sound result is obtainable. Owing to the tendency of the metal to develop blow or gas holes, special attention must be paid to the drying of moulds and cores. Skin-drying of moulds will produce most disastrous results.

Core Making

Great care and attention must be paid to the core irons and core barrels. All core grids for pans, vessels, bends, pipes, etc., must be constructed with a centre bar or ring strong enough to carry the core, but have lightly constructed fins or fingers radiating from the centre bar or ring. At least 2 in. clearance should be allowed between the end of the finger and the side of the core box. The reason for this construction is to simplify the stripping of the casting before annealing.

All core barrels should be straight and smooth with ample holes drilled or cast in to allow free escape of air whilst the cores are being dried. About 2 in. or 3 in. from each end of the core barrel, holes should be drilled or cast large enough, according to the size of barrel, to allow it to be withdrawn from the casting immediately it is set.

The main point the coremaker has to keep before him is that the core has to be quickly broken up after the casting of the mould. The reason for this will be fully realised when the stripping operation is explained. For cores made with a barrel, the usual trestle practice is followed, straw or wood rope used, clayed up in the usual manner and then loamed up to size. For core-box work, sea-sand cores with an oil-sand binder are essential. This is necessary not only for allowing contraction to take place but also to make less laborious the mould stripping operation after casting.

Casting

This operation, with cupola-melted metal, is undoubtedly a most important one. Referring back to the analysis at the beginning of the article it will be noticed that the metal must not contain more than 0.80 per cent. carbon, but as cast-iron scrap is used in the proportion of 2 to 1 of ferro-silicon, the total carbon in the metal is approximately 2.50 per cent.

The following method is used to reduce the carbon content: The metal is tapped from the furnace at 1,700 to 1,800 deg. C. It is run into shanks or ladles which after being filled are allowed to stand, whilst the metal is constantly agitated with bars. As the temperature of the metal falls the carbon is thrown out on the surface in the form of graphite. This has to be constantly raked off the surface of the metal. When the temperature of the metal has dropped to approximately 1,400 deg. C. the carbon is then reduced to the figure mentioned in the analysis and the metal is ready for pouring.

If the electric furnace is used for melting, the above procedure is unnecessary. The use of the electric furnace enables plate and girder steel scrap to be used with the ferro-silicon. As this scrap is obviously low in, or free from, carbon, the metal can be used for casting immediately it is released from the furnace. This is one very natural advantage the electric furnace has over the cupola.

Stripping the Casting after Teeming

Here is another operation where no time should be lost. As soon as the castings are set, they have to be stripped from the mould—all core irons being immediately broken out—and placed in annealing furnaces before they go black. The castings must, in most cases, retain some redness in colour as they are being put into the annealing furnace, otherwise the sudden change in temperature would have a tendency to crack them.

The reader will fully appreciate the necessity of teamwork during the stripping operation with castings of 2 cwts. to 40 cwts. Everything has to be carefully planned beforehand and allowance made for contingencies.

Annealing

This process is the one which if efficiently carried out will permit high-silicon iron castings to be successfully manufactured. In the writer's opinion it is the most important of all the processes from the point of view of preventing cracked castings in manufacture and giving longer life and more efficient working quality when put to work in the field.

Two types of furnaces are used—one being of the muffle type with a door on the front which rises and falls as required, and is counterbalanced by a balance weight. On the front of the furnace is a hearth, level with the floor of the furnace, *i.e.*, about 2 ft. from the ground. The castings are brought from the moulding floor after being stripped and are placed on the hearth to facilitate pushing into the furnace. This type of furnace is suitable for castings of light to medium section, say, up to ¾ in.

When the casting and stripping operations are finished the furnace is sealed and heated up to 750 to 850 deg. C. It is held at this heat for 4 to 6 hours. The furnace is then allowed to cool to room temperature and the castings are ready to send to the dressing shop. The cycle of operations takes approximately 24 to 36 hours.

For larger castings both in size and section a soaking-pit type of furnace is used. It is approximately 10 ft. by 10 ft. by 9 ft. deep. The door is on the top and is lifted off by crane power. The castings are carried and lowered into the furnace also by crane power. Great care and skill are required in the packing of this furnace. The castings must be so arranged that they cannot distort under heat and also the hot gases must have free circulation round the castings so that even heating and cooling is obtainable. After the furnace has been filled the cover is placed in position and sealed. The temperature is then raised to between 750 and 850 deg. C. and kept at this heat for 12 hours. After 36 hours the dampers are lifted and the castings allowed to cool to room temperature. The whole operation takes 72 to 96 hours according to the size and type of casting.

Dressing

The castings have to be handled with exceptional care in the dressing shop. Owing to the hard and brittle nature of the metal the castings cannot be chipped or filed. All runners and fins have to be cleaned off with a

(*Continued on page* 64.)

Institute of British Foundrymen

WEST YORKSHIRE BRANCH STAGES A SUCCESSFUL ANNUAL DINNER

In spite of pressure of work, the black-out and other conditions of the times, members of the West Riding of Yorkshire Branch of the Institute of British Foundrymen, which has maintained its programme of monthly meetings, arranged a successful dinner in Bradford on January 11. The gathering differed from the annual dinner held in peacetime in two respects: a dance to follow the dinner was considered impracticable, and the attendance was somewhat smaller. There was a notable absence of visitors from any considerable distance, including Institute headquarters.

Mr. H. A. MacColl, B.Sc. (Branch-President), presided, and was supported by Mr. Joseph Hepworth, M.P. (Past-President of the Institute and of the Branch), the Lord Mayor of Bradford (Alderman Wm. Illingworth, J.P.) and the Acting Lady Mayoress (Mrs. Douglas Illingworth); Councillor Louis Jessop; Mr. F. K. Neath, B.Sc., Mr. H. Forrest, Mr. A. S. Worcester and Mr. W. G. Thornton (all past Branch-Presidents); and Mr. S. W. Wise (Hon. Secretary of the Branch). Most of the officers and members of the Branch were accompanied by their ladies, and there were a number of other visitors.

Apologies for inability to attend were received from the President of the Institute (Mr. W. B. Lake); the Institute's Senior Vice-President (Major Miles); the General Secretary (Mr. T. Makemson); Mr. S. Carter; Mr. W. Ferrand; Mr. F. Oldershaw; and Principal H. Richardson (head of Bradford Technical College).

Preparing for the Aftermath

MR. JOSEPH HEPWORTH, M.P., proposing a toast to the visitors, said he was glad that the foundrymen of West Yorkshire, unlike some people and some societies, had not considered that everything of a communal or social nature must be suspended as soon as war broke out. They had carried out their programme for the session last winter and were doing so again this winter. They had decided, as the national slogan put it, to "Go To It" in their Institute interests as well as in the foundry. When he had invited one or two friends to come to the dinner and they had asked, "What is the Institute of British Foundrymen?" he had replied that the foundrymen were the beginning and the foundation of everything in the engineering industries.

Everybody, admittedly, was very much concerned with problems of the present time, but they must not neglect the necessity to look to the future as well. After the war the biggest contribution to the building of a new world would come not from the Dictators, but from men who had maintained research such as the Institute was encouraging. It might be urged that from the laboratories had come the dreadful machines of destruction occupying so much attention at present, but it was no fault of science or the scientists that their work had been put to such use; it was the fault of those who had misapplied their discoveries.

The foundry industry had to maintain research in science and engineering as much as any other industry, because it had to be realised that the world after the war would be a world of keen competition. When peace came the scientist and the engineer would be called upon to help in developing this country's trade abroad, and so far as the foundryman's own industry was concerned, Mr. Hepworth said he had no fears as to its capacity to hold its own with any foreign competitor.

The LORD MAYOR OF BRADFORD (Alderman Wm. Illingworth), responding, said he had listened with much interest to Mr. Hepworth because it had sometimes occurred to the Lord Mayor that Bradford and district had had a good deal of misfortune in the loss of some old and important engineering undertakings. It was good to know there was an organisation such as the Institute which was doing valuable work in maintaining the prestige of one phase of engineering and which might help in bringing back more industries to the district and a renewed prosperity in engineering activities. The foundry trade, like other skilled callings, had made great strides through the conduct of scientific research.

The Lord Mayor concluded by saying he was convinced there was every justification for the claim that foundrymen were contributing greatly to the nation's war effort; without the foundry worker there would be no engineering, and without engineering we should be in a sorry plight in a war of this kind.

Institution or Institute?

COUNCILLOR LOUIS JESSOP, proposing the toast of the Branch, said that when he was invited to the dinner he was glad to accept, but wanted to know a little more about the Institute and its activities. He was told it was, in large measure, an educational organisation for the advancement of foundry work and knowledge, etc., etc. That was very satisfactory but it was all the information he got and he wanted more about the "etceteras," so he had to put on his thinking cap. First, he felt he must memorise the title—Institute of British Foundrymen. That was not quite easy, so he tried abbreviating it, but when he found it became "Institute of B.F.'s" he felt the abbreviation was inappropriate. He himself was a member of the Institut*ion* of Electrical Engineers and he knew something of the Institut*ion* of Mechanical Engineers, and he would be glad if somebody could inform him as to the precise distinction between an Institut*ion* and an Insti*tute*. From the dictionary he gathered that an institution was a corporate body, whereas an institute had something to do with literature and science. Now he was wondering—finding that the Institute of British Foundrymen was also an incorporated body—whether he ought to ask the members to change the name to Institution or to ask the other bodies to change to Institute.

British foundrymen (continued Councillor Jessop)—from the youngest student to the works executive—whether engaged in the casting of steel, iron or non-ferrous metals, never had a greater opportunity than they had to-day of proving to the whole world, friend and enemy alike, that the Institute of British Foundrymen was a combination of craftsmen and scientists superior to that of any country in the world. The casting of molten metals was one of the most ancient of the arts and sciences, but to-day the foundry was turning out castings more intricate than any it had been called upon to make hitherto. It took a good draughtsman some time to put those designs on paper, and it took a good patternmaker some time to find out how to make the mould and the core in order that the job would go through the foundry without being sent back, in spite of the traditional never-ending difference of opinion between the foundryman and the patternmaker. There always had been this difference of opinion and perhaps always would be, but in the end the jobs went through successfully and gave good service.

A few days earlier, Mr. Jessop said, he had passed over the High Level Bridge at Newcastle, built in 1849, with six spans 125 feet long, each span having four arches, all in cast iron—a monument to the craftsmen of earlier days. Since that bridge was built far greater knowledge of the constitution of metals had been attained, but the bridge was still there, doing its job after all those years. The Institute, he understood, was the gathering ground for all that was best in the latest developments of foundry work, both practical and scientific. He urged them to see to it that they did not pigeon-hole those developments and allow them to lie dormant. They should encourage the young men to study them and in doing so put into practice the good intentions of those men who first gathered together as a Foundrymen's Association in former times and twenty years ago obtained the Charter for the Institute of British Foundrymen.

Overcoming Wartime Difficulties

The BRANCH-PRESIDENT (Mr. H. A. MacColl), responding to the toast, said it was a fact that the gathering was a somewhat thinner version of its normal self, but there were ample explanations of this in prevalent war conditions. However, they regretted the absence of some friends from distant parts of the country who would normally have been with them. There were also a good many of their own members working on Saturdays and even Sundays, and he was quite convinced that one or other of these reasons accounted for the absence of some well-known faces. There was, of course, the type of person—not in the membership of that Branch, he believed—who took a pleasure in the sort of self-martyrdom which made the war a reason for suspending everything of a social nature and who, after the war, would no doubt speak large and long about the great self-sacrifice undertaken in that direction!

Quite a number of kindred institutions had adopted that attitude. Yet the war was gloomy enough without aiding it by excluding all activities except those directly contributing to war. The West Riding Branch of the Institute resolved at the outset of war to carry on its programme of meetings, Papers and discussions, and on the same basis it resolved to carry on also with the annual dinner, its one social relaxation, even though they realised well enough they would meet difficulties and would probably be deprived of the company of some of the distinguished guests from a distance. They certainly had had their difficulties, particularly about the dinner gathering, and their stalwart Hon. Secretary, Mr. Wise, had, as usual, shouldered the bulk of them, for which they should all honour him.

For some reason the foundry industry seemed always to have been looked upon as a poor relation in the engineering trade. He flatly denied that and claimed it to be not only the backbone of the industry but the whole skeleton. The basic component of any engine was the metal casting, whilst the other forms of metal—bar, billet, sheet and the like—were based on the ingot, and the ingot was the product of the foundry. So he suggested that the industry was the foundation of all aircraft, naval or army mechanised equipment, and the achievements gained thereby could be attributed in no small measure to the contribution made by the foundrymen.

In the course of the evening musical entertainment was provided by Miss Alice Moxon (soprano), Mr. Craven Jowett (baritone) and Mr. Percy Monkman (entertainer), with Mr. Jn. Brayshaw at the piano.

Problems in Foundry Practice

SOUTH AFRICAN EXPERIENCES RECOUNTED AND EXAMINED

Considerable interest was aroused by a recent "Problem Evening" held by the South African Branch of the Institute of British Foundrymen in Johannesburg. The meeting was very well attended, and several members took the opportunity of presenting practical problems for discussion.

Use of Coal Dust

The use of coal dust in foundry practice—a subject which has aroused considerable discussion at previous Branch meetings—was once again prominently to the fore. MR. P. L. WARD described an experiment, carried out for purposes of comparison, with two simple castings, cast in the same box and by a common runner. The first was cast in sand to which coal dust had been added in the proportion of 6.8 per cent., and the second was cast in sand only. The skin of the first sample was obviously superior to that of the second.

MR. H. HOLDSWORTH said that when he first used coal dust he found it rather an expensive item, since the cost was £5 per ton. However, after giving coal dust a trial he decided to continue with its use. He considered it necessary for individual foundries to determine the percentage and grade which gave the best results. In the case of general castings from ¼ in. up to ½ in., a fine grist was required. A coarse, pulverised coal dust would not give good results. Excessive coal dust would prevent the metal from running. As to the use of coal dust for thin castings, he considered that the addition of a small amount of "carbon blacking" would in all probability give a still better skin. Where castings ranging in thickness from ¼ to 4 in. were handled, three different grades of coal dust should be available. Mr. Holdsworth added that pulverisation was expensive, and the only solution was for each foundry to have its own pulveriser.

MR. D. LION-CACHET recalled that at the previous meeting of the Branch, the need for high volatile and low ash content had been mentioned. He had approached the Transvaal Coal Owners' Association for information, and had learnt that no Transvaal coals had an ash content of less than 13 per cent. He inquired whether Natal coal was any better, and was told that certain grades of Natal coal had an ash content of less than 10 per cent. Subsequently a local dealer claimed that he could supply coal dust with an ash content of under 10 per cent. He (the speaker) had therefore placed an order, so as to determine whether the ash content did, in fact, make any difference. Mr. Lion-Cachet wondered if Mr. Holdsworth had noticed any difference in the ash contents of Transvaal and overseas coals. In other words, was a higher percentage of coal dust required in the Transvaal than overseas, in order to give practical results?

Initial Experiences

MR. HOLDSWORTH replied that, to the best of his knowledge, it was not necessary to add larger percentages of coal dust in South Africa than overseas. A foundry starting to use coal dust would probably find at first that results did not come up to expectations; but it should be realised that a considerable amount of the coal dust lying in the sand near the casting was destroyed, since most of it went to the mill. Once the sand was saturated, however, the percentage which had to be added decreased accordingly. It was necessary to apply common sense to obtain the best results.

MR. WARD added that the volatile content of the coal dust used by Mr. Holdsworth and himself varied in the first samples from as low as 24 per cent. to as high as 32.6 per cent. In regard to size, he considered that the coal dust should be ground much finer than the sand.

DR. MARAIS agreed that Natal coals were lower in ash content. Where coal with too low an ash content was used, there might be danger of fusing-on when casting at a high temperature. He mentioned that he was carrying out research work in connection with producer gas, and among the by-products obtained was retort carbon with an ash content below 2 per cent. He would like to give this material a trial.

A MEMBER asked what type of crusher was used for preparing coal dust and on what principles it worked.

MR. WARD said the crusher carried a very heavy shaft and a disc of about 1-ft. dia. Eight steel impellers were attached to the disc. A fan was provided at the discharge end of the shaft, and near this fan were four more blades, the exact position of which regulated the fineness. The machine crushed about 1½ tons per shift and required about 7½ h.p. for operation.

MR. HOLDSWORTH said that mixing was not difficult. The facing sand could be put through the mill with shovels. Once the natives became accustomed to handling the shovels and filling the machine, they began to notice little peculiarities in the load of the machine and knew when sufficient sand had been provided. The coal dust was then added and the length of time required for mixing could be very accurately gauged, resulting in an even mixture throughout.

An Ingot-Mould Casting

MR. R. C. I. SNOW asked if Mr. Holdsworth would recommend 7 per cent. coal dust for a 7-in. ingot mould.

After asking for further details, MR. HOLDSWORTH replied that, since the ingot mould was not cast in green sand, the question of coal dust did not arise. However, he saw no reason why a good clear skin should not be obtained with green sand. His organisation made castings 4 in. or 5 in. thick, and weighing up to 600 lbs. Being informed that the castings under discussion weighed 650 to 700 lbs., Mr. Holdsworth said he would not risk undertaking such a casting in green sand, either with or without coal dust.

MR. STONES thought that too little attention was paid to the quality of sands used in South Africa, relative to the use of coal dust. Scientific tests should be made before coal dust was added.

MR. HOLDSWORTH said that he had a works manager who knew the exact composition of his sands and the addition of coal dust was systematically carried out. Quantities were judged, however, by their effect on castings.

MR. WARD pointed out the necessity of knowing the percentage of volatiles remaining after the sand had been in the foundry for some years, some going out every day and being replaced by new sand coming in. He found that the only effective method was one based on a sample of the original sand, which was dried and ignited to 750 deg. C. in a platinum crucible with the lid on. The same procedure was then followed with a sample to which coal dust was added. From the data thus obtained the volatiles could be estimated. This system was based on the fact that the coal-dust-free sand lost a certain weight because of the organic matter it contained.

MR. LION-CACHET appreciated that, to a foundry which had been using coal dust for some time, percentage was less important than to a beginner. Was it possible to give the percentage of coal dust which beginners should add to their first sample in the case of castings up to, say, 3 in. thick?

MR. HOLDSWORTH observed that in such a case the metal thicknesses would be fairly consistent, which was an advantage. About 10 per cent. might be added in the early stages, the percentage being controlled as the sand became saturated.

DR. MARAIS suggested that the estimation of the coal-dust content of sand by ignition loss might be deceptive because ordinary sand lost some of its volatile substances. Allowance had to be made for the fact that not all the loss was due to the coal dust.

MR. WARD stated that due allowance was made in his calculations for this factor.

Shrinkage Experiments

MR. LION-CACHET said that there was now a tendency to make castings with greater accuracy than hitherto. This was how he came to notice an unusual phenomenon. He was asked to make a small aluminium casting which, in order to save machining, had to be as accurate as possible. He rejected the idea of using moulds and decided to make the casting complete in cores. The pattern was made very carefully, as were also certain steel parts which had to be inserted into the mould. When the casting was received from the foundry and the steel parts were introduced, it was found that the aluminium had shrunk. This led him to investigate the question of shrinkage. He recalled a Paper read by Mr. Holdsworth on a tube mill liner which had shrunk ¼ in. more than other castings which were exactly similar.

It seemed to him that in investigating the apparent inconsistency of shrinkage, there were two types of shrinkage to be considered—liquid shrinkage and solid shrinkage. In his opinion, the patternmaker was not concerned with liquid shrinkage, but only with the solid shrinkage which took place between the metal solidifying and attaining room temperature. To investigate shrinkage, he cast some experimental bars, each 14 in. long with two notches exactly 12 in. apart. A set of four bars, respectively 1 in., ¾ in., ½ in. and ¼ in. square, was cast in each of four different materials: gunmetal, phosphor bronze, pure aluminium and aluminium scrap. To make the moulding more accurate, the bars were placed on a board, and the patterns were given the correct amount of taper. All measurements were carried out with a micrometer. The following were the results obtained:—

	1 in.	¾ in.	½ in.	¼ in.
Gunmetal, 11 13/16 in.	15	5	— 8	— 10
Phosphor bronze, 11 13/16 in. ..	25	20	15	10
Pure aluminium, 11¾ in. ..	21	29	33	57
Scrap aluminium, 11 13/16 in. ..	5	10	1	11

Thus the amount of contraction between the notches of the bars cast in gunmetal was 25/1,000 greater in the ¼-in. bar than in the 1-in. bar, and the same effect was experienced with the two sets of bars cast in phosphor bronze and aluminium scrap. With pure aluminium, however, the effect was exactly the opposite. Why was that? All the castings were run from the same runner under exactly the same conditions. He also wondered why the contraction apparently differed with the thickness of the section. It was mentioned in the "Moulder's Handbook" that the contraction for thin brass was 3/16 in. and for thick brass 1/16 in. He would appreciate suggestions.

DR. MARAIS pointed out that pure aluminium was a substance with a constant melting point, whereas the other substances were mixtures.

In the case of pure aluminium, there was an outer shell which chilled more or less solid, and the subsequent liquid shrinkage was not so great. This was the only explanation he could suggest.

Clogging in Core Boxes

MR. WARD brought up the question of the clogging of sand in core boxes and occasionally in patterns. Core boxes made of the same wood (mainly pine), and varnished in the same way, seemed to vary considerably in this respect. In some, clogging was experienced until fifty or sixty cores had been made, after which they seemed to become seasoned. Why should some boxes be more liable to clog than others?

A MEMBER suggested that the sand might be damper in one core than another, and that the timber used for some of the boxes might have been damp. Clogging depended to a very great extent on the dampness of the timber and on the varnish which was applied.

During discussion it was stated that better results seemed to be obtained by allowing the first coat of varnish to dry out thoroughly before the second coat was applied.

Another MEMBER described a curious experience when making a number of small chill castings from aluminium scrap. Many castings cracked at the neck. Saltpetre was used as a flux to eliminate gases, but the trouble was not overcome until double melting was tried in order to provide a double fluxing. This proved the solution of the problem.

Swelling in Castings

At the President's suggestion, MR. HOLDSWORTH gave members further particulars of the swelling in castings which was mentioned at the previous meeting. He said that there had been occasional trouble with the first tap of metal. The peculiarity was that, when the metal was cast, a reaction took place on its reaching the freezing point. This action varied in violence, and in some cases would show in the runner bush by rising even to overflowing—a somewhat similar action to that experienced when casting steel that had been oxidised. At other times, the action started after the metal in the down runner had set, and the casting swelled. Since a chill was used on the bottom, the metal took the line of least resistance and pushed up the sand in the top box. Sometimes the metal would behave in a normal way and sink in the bush, and when the casting was seen next day there would be a slight hollowing on the back (in the case of a heavy casting), but this would be partially filled by metal that had bled back. As was often the case with bronzes that had been cast too hot, the tin would sweat out in blobs.

Bricks were cast in cast-iron moulds. The action was practically the same in all cases, since the metal could not push the mould apart. After removing the runner head, the metal would ooze upwards until there was a lump on the top. Even when this had been stopped, there would be a hole in the centre which blew up little sparks like a miniature Roman candle. As stated earlier, these reactions were not always noticed. It was thought that a poor-quality coke used to preheat the furnace might have had some contaminating effect, so good fuel was used, but that had no effect. Since it was essential to start casting early, blowing was commenced as soon as the bed was burnt. The charges were put on and they probably lay on the bed before it was completely burnt out for approximately 20 to 30 mins. before blowing was started. It was wondered whether this might be the cause, and the bed was therefore completely burnt through, and as soon as three charges had been put on blowing was commenced. The result was negative. The

(*Continued in next column.*)

Taking Brinell Hardness Test Readings

The Brinell hardness test, if carried out properly, is one of the most useful used in ferrous metallurgy, and one which should give strictly comparable results in all laboratories and works. Yet it is surprising to learn, as recorded recently in one of our American contemporaries, that two important works in the United States failed to arrive at the same unit number even when reading the same impressions. Such a state of affairs obviously called for an immediate investigation, which yielded the astonishing fact that the differences obtained were due to the respective microscopes employed. In one case the microscope was correctly calibrated on the prescribed standard, and in the other the microscope had been adjusted to give a good focus irrespective of a definite dimensional check.

In this country, where the Brinell test is very extensively employed, it is difficult to believe that such circumstances could exist, but in view of what has happened in the case referred to above, it will be well to stress the point and to direct attention to the one and only correct procedure. The Brinell test is almost as simple as any test can be; all that is required is a reasonably clear, flat surface on the object to be tested, a firm bed, a suitable load and pressure gently applied for a predetermined time. After that all depends on the fixed microscope, which should be calibrated *and locked* against the graduated scale. If attention is paid to these points there seems no reason why variations should be found, especially when reading the same impression.

There is another very important point, and that is that the microscope should be calibrated periodically, the frequency depending on the extent to which the apparatus is employed. Where it is used in routine testing in the heat-treatment shop, calibration should be carried out at least once per day, for in spite of the lock the telescope does slide slightly, thus introducing an error, depending on the extent of the movement.

Fortunately, in our experience, discrepancies of this nature are rare, but if any reader has overlooked the question of checking the microscope against the standard scale, he should do so immediately, and thus assure himself that, by taking that simple precaution, he has eradicated the possibility of error.

(*Continued from previous column.*)

same method was adopted on two more occasions, except that the bed was made higher each time by approximately 4 in. to 6 in. The result was still the same. It was now proposed to analyse each cast in conjunction with the foundry. These happenings recalled the speaker's apprenticeship days, when to ensure that the castings would machine perfectly, the first ladle, containing approximately 15 cwts. of metal, was discarded.

DR. MARAIS suggested analysing the iron for hydrogen, as it seemed to him that the trouble might be caused by hydrogen, which was very persistent.

Presentation of Prizes to Students

Prizes were then presented to Raymond Victor Tearman (Benoni), who was first in the Trade Theory for Patternmakers and Moulders (National Technical Certificate, Part I), and to Ralph Allan (Germiston), who obtained the highest marks in the Trade Theory for Patternmakers and Moulders (Preliminary Technical Certificate).

Distribution of Steel

USE OF STANDARD FORM "M"

An important step was taken in the last quarter of 1940 to put the procedure under which Government departments authorise the purchase of steel on a uniform basis. All Government departments are now issuing their authorisations to acquire steel on a standard form "M." This form gives the necessary authority to a contractor to order steel by quoting the symbol of the Government department concerned, the department authorisation number and the period for which the quantity of steel authorised may be ordered. The steel may only be ordered for the purposes stated on the authorisation form or to replace steel used for the purposes referred to on the form; also, in placing the order with steel product makers, the contractor must state "authorised on Form 'M'" to show that he has received the necessary authorisation form.

The authorisation given to contractors enables the firm either to buy directly from the makers of steel products up to the tonnage specified, or to issue sub-authorisations also on Form "M" to sub-contractors for any part of the tonnage authorised. Contractors requiring to issue sub-authorisations under their own authorisation can obtain the necessary copies of Form "M" from the Government department, or contractor acting for a Government department, from whom they received their own authorisation.

The foregoing procedure covers 90 per cent. of the steel requirements of the country, and its general purpose is to ensure that firms only acquire steel for purposes approved by Government departments in connection with their various programmes of munitions, aircraft, etc., and within the allocations given by the Government to each of the departments.

Exceptions

In the case of equipment required by factories which may be engaged on work for various Government departments, or on civil work, it may not be possible to obtain an authorisation from a Government department, as the work involved is not the responsibility of one particular Government department. In this case permission to acquire the steel involved is obtained by a licence from the Iron and Steel Control, to whom application should be made in all cases where the steel is not covered by an authorisation on Form "M" from a Government department.

Apart from the licences issued by the Iron and Steel Control, the only exception to the use of Form "M" is in the case of certain authorisations issued by Government departments prior to October last. In these cases the standard Form "M" was not yet in use, and the departments gave the necessary authority to quote their symbol, etc., on their own forms. In certain cases, therefore, the contractor may not be in a position to state that he has been authorised on Form "M" and, provided that the particulars as to department are properly set out, steel can, in the meantime, be ordered under these pre-October authorisations. In none of these cases, however, may any particulars regarding Government contracts, whether they are contract numbers or other details, be quoted in order to acquire steel unless they are part of a written authorisation given by a Government department specifically for this purpose.

Alloy Steel Purchases

Recently a further arrangement has been made whereby alloy and carbon steel is allocated separately between the Government departments, and as a result of this arrangement a special Form "Ma" is used to authorise alloy steel. Until this new form can be printed and brought into general use, Government departments will stamp the existing Form "M" "Alloy Steel" when the purchase of alloy steel is authorised. When alloy steel is not covered, the form will be stamped, "This form does not authorise the purchase of alloy steel." Care should be taken, therefore, to ensure that no alloy steel is ordered under an authorisation which specifically excludes the purchase of alloy steel.

MR. JAMES WILSON, formerly with Butterworth & Dickinson, Limited, founders, of Burnley, has died, aged 81 years.

Metallography of Inclusions in Cast Irons and Pig-Irons

By H. MORROGH (British Cast Iron Research Association, Birmingham)

(*Continued from page* 39.)

Influence of Pouring Temperature

In cast irons poured at fairly low temperatures (<1,350 deg. C.) manganese sulphide occurs in typical compact idiomorphic crystals, whereas in irons poured at high temperatures (>1,400 deg. C.) the manganese sulphide tends to occur in recognisable dendritic forms in the case of high-sulphur irons, and as "anchor-shaped" crystals in low-sulphur irons. Portevin and Castro[37] have observed this latter form in cast irons. A typical example of an anchor-shaped manganese sulphide dendrite is shown in Fig. 6, and a well-formed manganese sulphide dendrite in a hot-poured high-sulphur iron is illustrated in Fig. 7.

Norbury[38] has shown that the primary microstructure of cast iron is considerably affected by the pouring temperature. For instance, in the case of hypo-eutectic cast irons, the primary austenite dendrites decrease in length and become more compact with decreasing pouring temperature. It is obvious from the above observations that manganese sulphide behaves in a similar manner (with regard to pouring temperature), with the one difference that the manganese sulphide dendrites formed at high temperatures will tend to float up to the surface of the metal, by virtue of their low relative density. The manifestly dendritic form of manganese sulphide in hot-poured samples is the exact analogue of the long, well-formed, primary austenite dendrites, while the small, typically idiomorphic crystals correspond to the short primary austenite dendrites. The fact that manganese sulphide exhibits the same morphological changes with decreasing pouring temperature as do the primary metallic dendrites, still further confirms that manganese sulphide is soluble in molten cast iron, from which it is deposited in the solid form as cooling proceeds.

FIG. 6.—"ANCHOR-SHAPED" MANGANESE SULPHIDE DENDRITE IN LOW-SULPHUR, HOT-POURED CAST IRON. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

A Morphological Phenomenon

Occasionally, small spherical holes filled with metal are observed in the centres of manganese sulphide crystals. This fact has been recorded photomicrographically by Allen.[39] The examination of a large number of samples of cast iron containing well-formed manganese sulphide crystals has suggested quite a simple explanation for this curious morphology. This is illustrated in Figs. 8(*a-d*), which were taken from the same sample as that used for Fig. 7. Manganese sulphide begins to grow in the manner characteristic of dendrites having a cubic crystal structure. The initial dendrite has six outgrowing branches radiating from a common centre. This is shown in Fig. 8(*a*). At first these small manganese sulphide dendrites are rounded, but with a fall in temperature, the tips of the dendrite branches gradually take on an "arrow-head" shape (Fig. 8(*b*)). The next stage of growth results in the tips of the arrow-heads becoming angular, and the arrow-heads on different dendrite branches grow out to meet each other (Fig. 8(*c*)). Finally, the joining up of the dendrite branches is completed at the extreme ends of the dendrites, and a perfect idiomorphic crystal is obtained with small holes containing entrapped metal (Fig. 8(*d*)). The number of such spheroids of entrapped metal which are visible must obviously depend on the particular section which the surface of the micro-specimen cuts through the manganese sulphide crystal.

FIG. 7.—MANGANESE SULPHIDE DENDRITE IN SAMPLE CONTAINING 0.280 PER CENT. S AND 0.83 PER CENT. MN. POURING TEMPERATURE APPROX. 1,600 DEG. C. 4-MM. OBJECTIVE. UNETCHED. × 500.

Inclusions in MnS

Very rarely, minute black specks have been observed in manganese sulphide, but they were so small that it was impossible to say definitely whether they were holes or small inclusions, even by the use of the highest available magnifications. However, on one occasion, samples of manganese sulphide containing large, well-developed dark crystals were obtained. The melt in question was carried out as follows: 195 g. of Swedish white iron and 6½ g. of 80 per cent. ferro-manganese were melted in an alundum crucible, using a high-frequency induction furnace; the metal was superheated as far as possible, then 3 g. of iron sulphide were added and the furnace was shut off, the crucible and its contents being allowed to cool in air. The resultant ingot was sectioned from top to bottom for microscopic examination. The original purpose of the experiment was to obtain some well-formed manganese sulphide dendrites. However, not only were dendrites present, but also large spheroids of this compound, indicating that the composition and temperature of superheating were such that the region of liquid immiscibility had been reached. A large number of idiomorphic and dendritic manganese sulphide crystals either contained, or were associated with, quite large crystals of a dark, grey-green compound, although the spheroids of manganese sulphide did not show this. Generally, these dark crystals were cubic in outline and they appeared to be much harder than manganese sulphide, above which they stood in considerable relief. A typical example of this inclusion is shown in Fig. 9. Occasionally the inclusion occurred in an elongated form, and when the length of the manganese sulphide dendrite happened to be sectioned by the polished surface, it was seen to occur in a particularly complex form along the dendrite. Figs. 10 and 11 illustrate these two latter modes of occurrence.

The chemical analysis of the sample gave 2.41 per cent. of manganese and 0.40 per cent. of sulphur. A comparison of the morphology of the dark inclusion with that of the manganese sulphide suggested that the cubic appearance in a compact idiomorphic manganese sulphide crystal was due to the fact that, actually, a cross-section of a manganese sulphide dendrite was being examined, and that the actual form of the dark inclusion was acicular, running the length of the manganese sulphide dendrites and having a cubic cross-section.

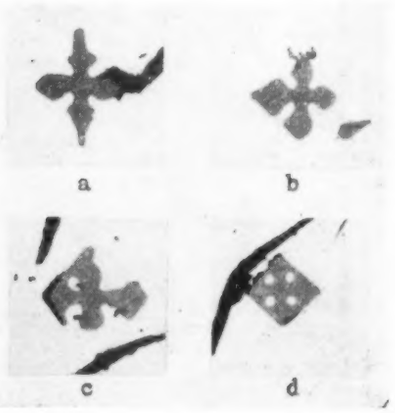


FIG. 8.—MODE OF OCCURRENCE AND FORMATION OF SMALL CIRCULAR HOLES IN MANGANESE SULPHIDE CRYSTALS. 4-MM. OBJECTIVE. UNETCHED. × 500.

Careful examination of the inclusion revealed it to have a faint greenish translucency, which was confirmed by its behaviour under polarised light between crossed nicols, when a bright green coloration was obtained, persisting in all positions of the stage. The conclusions to be drawn from the polarised-light examination are that the inclusion is either completely isotropic or cubic, and that it is at any rate partially transparent to green light. The observations made so far would seem to indicate this new inclusion to be probably manganese oxide, containing, perhaps, a small amount of iron oxide, FeO. Portevin and Castro[37] have reported that the addition of manganese (of the order of 1 per cent.) to oxidised iron results in the double-oxide inclusions becoming darker, and with high manganese contents the colour of the inclusions changes to green, with a high transparency.

Inclusions in Malleable Iron

In whiteheart malleable irons, where, as a rule, the manganese/sulphur ratio is low, iron sulphide is frequently found alone or associated with varying amounts of manganese sulphide. The line of demarcation between the two constituents is usually very sharp and straight, and sometimes iron sulphide occurs in a Widmanstätten formation in the manganese sulphide. These facts seem to indicate that either the iron sulphide or the manganese sulphide is formed in the solid state from either a manganese-sulphide-rich solid solution in the first case, or an iron-sulphide-rich solid solution in the second case. Such behaviour is, of course, indicated by the accepted equilibrium diagram for the partial system FeS-MnS, and also by the experiments of Whiteley, which have already been referred to. Further evidence on this point was obtained in the following manner: Pieces of white iron (used in the manufacture of whiteheart malleable iron) containing 0.10 per cent. of manganese and 0.187 per cent. of sulphur, were heated for 3 hr. at temperatures ranging from 750 to 1,000 deg. C. and quenched in water. The as-cast structure had fairly large amounts of iron sulphide with a small amount of manganese sulphide; the samples quenched from 950 and 1,000 deg. C. showed no iron sulphide, and those quenched from 900, 850 and 800 deg. C. contained only traces of iron sulphide, while the sample quenched from 750 deg. C. was very similar to the as-cast sample. It is interesting to remember this point in connection with the malleablising of white iron. Although an iron may show iron sulphide in the as-cast state, it does not necessarily mean that free iron sulphide will be present in the iron at the annealing temperature.

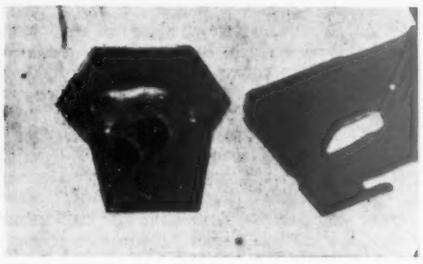


FIG. 9.—MANGANESE SULPHIDE CONTAINING DARK GREY-GREEN CUBIC INCLUSIONS. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

FIG. 12.—DUPLEX INCLUSION OF IRON AND MANGANESE SULPHIDE IN WHITEHEART MALLEABLE IRON. NOTE SHARP LINE OF DEMARCATION. 2-MM. OIL-IMMERSION OBJECTIVE. × 1,200.

FIG. 13.—SAME SPOT AS FIG. 12 BETWEEN CROSSED NICOLS. MANGANESE SULPHIDE REMAINS DARKER THAN METALLIC MATRIX, AND IRON SULPHIDE LIGHTS UP. × 1,200.

Crystal Structure of FeS

Iron sulphide has a hexagonal crystal structure[34] and, as would be expected, when examined under polarised light between crossed nicols it lights up four times for a complete revolution of the stage. This method of examination can be used very effectively to distinguish between iron sulphide and manganese sulphide, or between iron sulphide and manganese sulphide rich in iron sulphide. A typical example of a duplex inclusion of iron and manganese sulphide is shown in Figs. 12 and 13. The effect of the annealing on the inclusions in irons for malleablising is to spheroidise them. This is particularly noticeable in irons containing the duplex sulphide inclusions.

An improved technique has been developed for the preparation of cast-iron and malleable-iron micro-sections, which enables the actual internal structure of the graphite to be observed. The application of this technique to malleable iron samples has revealed that at least two different forms of temper-carbon nodules can exist. Generally speaking, the temper carbon occurring in whiteheart malleable iron is in a compact spherulitic form, in which the graphite crystallites have their basal planes orientated at right angles to the sphere of which the temper-carbon nodule can be considered to be composed. A typical example of this type of temper carbon is illustrated in Fig. 14. The "fluffy" graphite around the main body of the nodule is the hypereutectoid graphite, the amount and "fluffiness" of which depend on the annealing temperature, the stability of the cementite and the rate of cooling given to the sample. In blackheart malleable irons it was observed that the temper carbon generally existed in a form which, when examined by the improved technique, was revealed to be virtually an aggregation of small graphite flakes. At first it was thought that the two different types of temper-carbon nodule were the result of the two different types of annealing used in the production of whiteheart and blackheart malleable irons. This was disproved, however, when a piece of whiteheart malleable iron was discovered with the "graphite-flake-aggregate" type of temper carbon (Fig. 15). Examination of the sample revealed that the manganese content of the iron was sufficient to balance the sulphur content and that only manganese sulphide was present. Thus it became apparent that the real causes of the production of the two different forms of temper carbon lay, not in the different annealing treatments which blackheart and whiteheart malleable irons receive, but rather in the fact that, in general, whiteheart malleable irons contain iron sulphide, and blackheart malleable irons contain only manganese sulphide. This became more apparent when the mode of occurrence of the temper carbon was more closely examined.

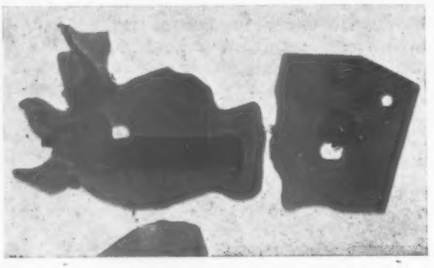


FIG. 10.—ELONGATED DARK GREY-GREEN INCLUSION IN MANGANESE SULPHIDE. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

FIG. 14.—SPHERULITIC TEMPER-CARBON NODULE IN WHITEHEART MALLEABLE IRON CONTAINING FREE IRON SULPHIDE. 2-MM. OIL-IMMERSION OBJECTIVE. ETCHED IN PICRIC ACID. × 1,000.

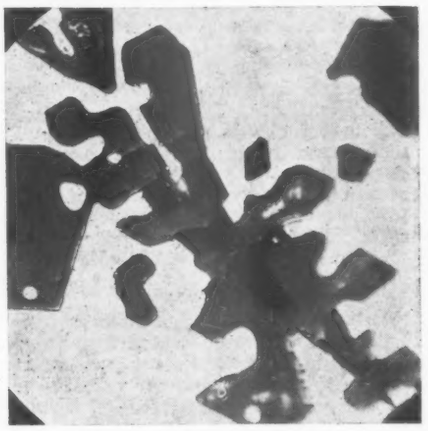


FIG. 11.—OCCURRENCE OF DARK GREY-GREEN INCLUSIONS ALONG THE LENGTH OF A MANGANESE SULPHIDE DENDRITE. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

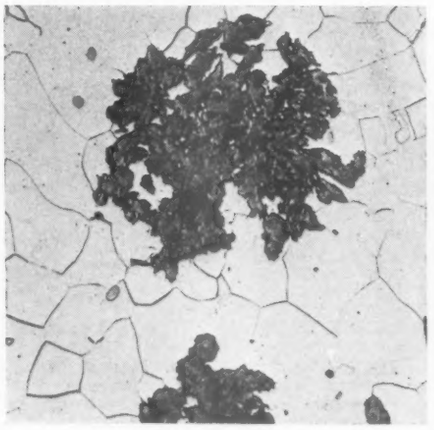


FIG. 15.—"FLAKE-GRAPHITE-AGGREGATE" TEMPER CARBON IN WHITEHEART MALLEABLE IRON CONTAINING SUFFICIENT MANGANESE TO BALANCE SULPHUR CONTENT. 8-MM. DRY OBJECTIVE, N.A.83. ETCHED IN 5 PER CENT. ALCOHOLIC NITRIC ACID. × 300.

Sulphide Nodules in Malleable Cast Iron

In whiteheart malleable irons containing iron sulphide, it was found that a large number of temper-carbon nodules had nuclei of iron sulphide. A typical example of this is illustrated in Fig. 16. So far, it has not been possible

to determine whether every spherulitic temper-carbon nodule contains an iron sulphide nucleus, since it appears that the nucleus will only be visible when the temper-carbon nodule is so sectioned that the polished metal surface cuts through the centre of the nodule. When the white iron used for the manufacture of whiteheart malleable is poured at a fairly high temperature, the resultant malleable iron frequently contains groups of spherulitic temper carbon joined together, forming an almost continuous and straight band of graphite. A typical example of this is illustrated in Fig. 17. The explanation of this phenomenon is fairly obvious when it is remembered that iron sulphide can act as a nucleus for the temper carbon. In hot-poured white irons, the primary dendrites will tend to be long, and in thin sections (such as are frequent in the malleable-iron industry) columnar. As a result of this, the extra-dendritic or eutectic regions will be likewise striated or columnar. Now, iron sulphide segregates to the eutectic regions of white irons and so it will be arranged more or less in straight lines radiating approximately at right angles to the cooling surface.

These iron sulphide inclusions will then act as nuclei for the formation of spherulitic temper carbon, which, if the inclusions are sufficiently close together, will give a continuous band of graphite. It is important to observe at this stage that only a few of the available iron sulphide nuclei actually behave as nuclei for the temper-carbon nodules. There are always far more iron sulphide inclusions than temper-carbon nodules. The question becomes further complicated when it is remembered that, although iron sulphide may be present as the free compound in the iron at room temperature, it is also possible that it is dissolved to some extent in the manganese sulphide at the annealing temperature. In this fact may lie the explanation of the observation that only a few of the iron sulphide inclusions behave as nuclei. In the case of irons containing duplex sulphide inclusions, some of the iron sulphide will tend to dissolve in the manganese sulphide, giving an apparently homogeneous type of inclusion. It is probable that with this state of affairs the manganese sulphide inclusions rich in iron sulphide do not act as nuclei for the graphite, but the relatively small amount of iron sulphide remaining undissolved does act in this manner, and so at room temperature, when the iron sulphide is reprecipitated, only few of the visible iron sulphide inclusions appear to have nucleated the graphite.

Schwartz[40] has reported and recorded photomicrographically the nucleisation of temper carbon by manganese sulphide. Unfortunately, the micrograph which he reproduced does not reveal the structure of the temper carbon. This investigator claims that graphitisation usually begins at a cementite/solid-solution interface.[41] Although no actual analyses are given, these remarks presumably apply to irons in which the sulphur content is balanced by the manganese content. The use of the improved polishing technique has, however, made it possible to observe the process of graphite-flake-aggregate temper carbon forming around manganese sulphide crystals.

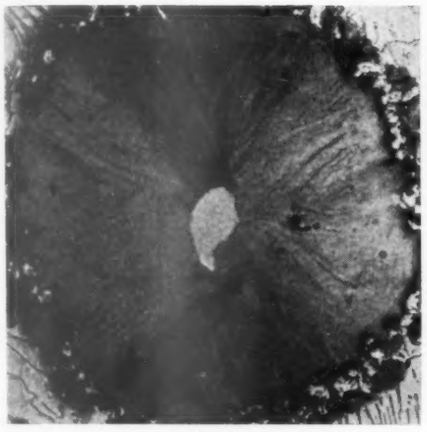


FIG. 16.—SPHERULITIC TEMPER-CARBON NODULE CONTAINING NUCLEUS OF IRON SULPHIDE. 2-MM. OIL-IMMERSION OBJECTIVE. ETCHED IN PICRIC ACID. × 1,000.

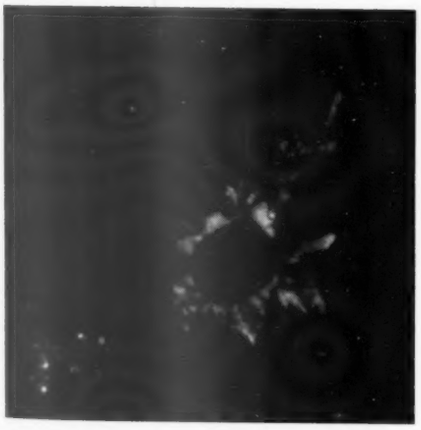


FIG. 19.—SAME SPOT AS FIG. 18 UNDER POLARISED LIGHT BETWEEN CROSSED NICOLS.

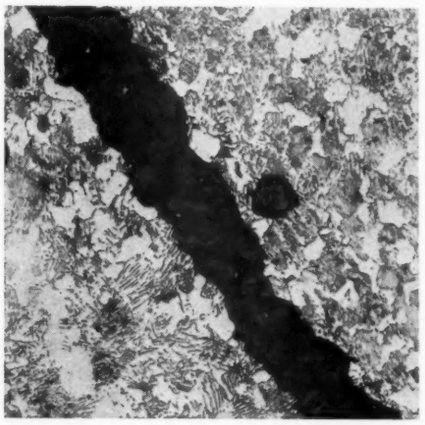


FIG. 17.—GROUP OF SPHERULITIC TEMPER-CARBON NODULES JOINED TOGETHER OWING TO CLOSE PROXIMITY OF THEIR IRON SULPHIDE NUCLEI. 16-MM. DRY OBJECTIVE. ETCHED IN PICRIC ACID. × 150.

FIG. 20.—OCCURRENCE OF GRAPHITE AROUND A MANGANESE SULPHIDE CRYSTAL IN EUTECTIC CEMENTITE AREA. 2-MM. OIL-IMMERSION OBJECTIVE. ETCHED IN PICRIC ACID. × 1,200.

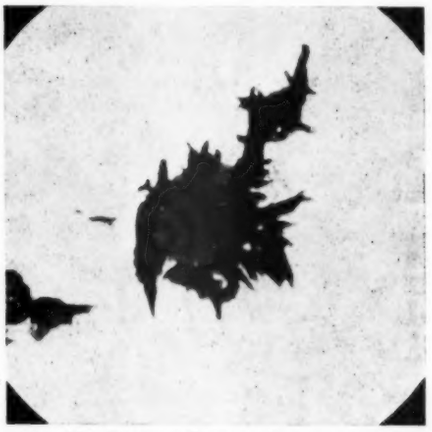


FIG. 18.—TEMPER CARBON FORMING ROUND A CRYSTAL OF MANGANESE SULPHIDE. 2-MM. OIL-IMMERSION OBJECTIVE. UNETCHED. × 1,200.

FIG. 21.—GRAPHITISATION OF HYPEREUTECTOID CEMENTITE IN ABSENCE OF MANGANESE SULPHIDE. 2-MM. OIL-IMMERSION OBJECTIVE. ETCHED IN PICRIC ACID. × 1,200.

Experimental Evidence

A piece of a 1.2-in. bar was annealed at a temperature of 1,050 deg. C. for 2 hrs. and then air-cooled. The analysis of the bar in the as-cast condition was as follows:—T.C, 1.92 per cent.; Si, 0.77; Mn, 0.38; S, 0.060, and P, 0.048 per cent.

Figs. 18 and 19 illustrate a typical graphite formation around manganese sulphide in this sample. The temper-carbon structure is, in this case, very different from the spherulitic structure. Fig. 19, taken under polarised light between crossed nicols, reveals the outlines of the numerous graphite crystallites, which, under normal vertical illumination, are not differentiated.

An examination of the etched structure of the annealed sample showed that a large number of the manganese sulphide crystals surrounded by graphite were actually situated in a eutectic cementite region. A typical example of this is illustrated in Fig. 20. It was also found that a considerable amount of the hypereutectoid cementite had apparently graphitised *in situ* without the presence of manganese sulphide (Fig. 21). Generally, the hypereutectoid graphite so formed was continuous with its cementite counterpart.

The joining up of several adjacent flake-graphite-aggregate-type temper-carbon nodules has been observed in blackheart malleable irons. Although this phenomenon is apparently analogous to that occurring with the spherulitic temper-carbon nodules, it has not, so far, been possible to demonstrate that it is caused in the same manner. A typical example of a continuous band of such temper carbon is illustrated in Fig. 22.

From the above remarks it is seen that the question of the nucleisation of graphite by manganese sulphide is more complex than that by iron sulphide. As Schwartz[42] has pointed out, the number of nuclei present for the formation of temper carbon is greatly affected by variations in other conditions, and by the introduction of a quenching treatment prior to the annealing. However, as far as is known at present, these facts only apply to irons in which the manganese is balanced by the sulphur, or in which no sulphides other than manganese sulphide exist. From the observations made above, the one certain and significant fact emerges, that malleable irons made from white irons containing iron sulphide, or a mixture of iron and manganese sulphides, have a very different form of temper carbon from irons containing only manganese sulphide. The fundamental explanation of this behaviour is still obscure, the more so since the presence or absence of these inclusions is not the sole factor affecting the number of graphite nuclei formed. Nevertheless, inclusions of this nature obviously affect the graphitisation of white iron to a great extent, and it may be important to try to reconcile the effects of manganese sulphide and iron sulphide with their different crystal structures.

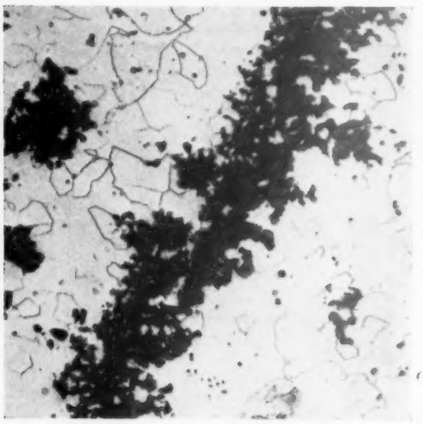


FIG. 22.—BAND OF "GRAPHITE-FLAKE-AGGREGATE" TEMPER-CARBON NODULES IN SAMPLE OF BLACKHEART MALLEABLE CAST IRON. 16-MM. DRY OBJECTIVE. ETCHED IN 5 PER CENT. NITRIC ACID IN ALCOHOL. × 150.

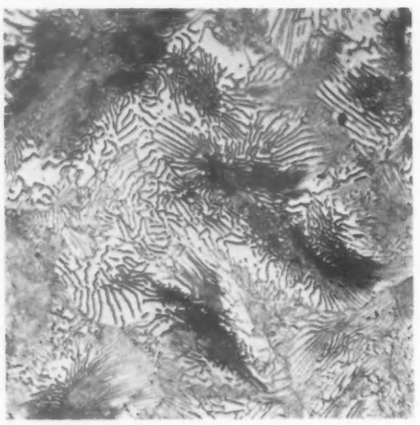


FIG. 23.—INTIMATE OCCURRENCE OF FINE AND COARSE PEARLITE IN IRON CONTAINING IRON SULPHIDE. FINE PEARLITE IS DARKLY-ETCHED CONSTITUENT. 4-MM. DRY OBJECTIVE. ETCHED IN PICRIC ACID. × 600.

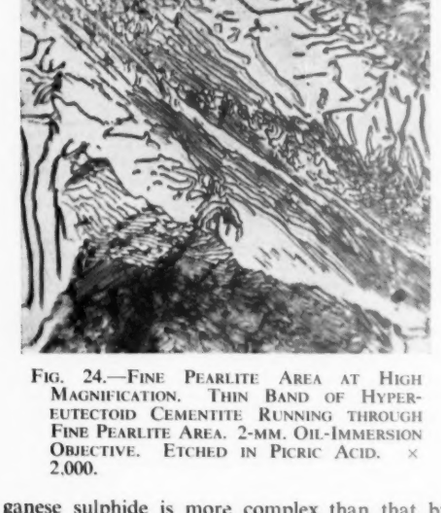


FIG. 24.—FINE PEARLITE AREA AT HIGH MAGNIFICATION. THIN BAND OF HYPEREUTECTOID CEMENTITE RUNNING THROUGH FINE PEARLITE AREA. 2-MM. OIL-IMMERSION OBJECTIVE. ETCHED IN PICRIC ACID. × 2,000.

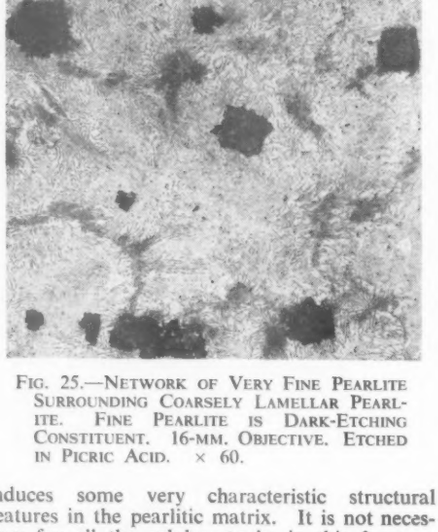


FIG. 25.—NETWORK OF VERY FINE PEARLITE SURROUNDING COARSELY LAMELLAR PEARLITE. FINE PEARLITE IS DARK-ETCHING CONSTITUENT. 16-MM. OBJECTIVE. ETCHED IN PICRIC ACID. × 60.

Iron Sulphide in Grey Iron

The presence of iron sulphide in grey or mottled irons of fairly large section frequently induces some very characteristic structural features in the pearlitic matrix. It is not necessary for all the sulphur to be in this form—a trace of iron sulphide will suffice. The structural characteristic referred to is the occurrence throughout the section of very coarsely laminated pearlite along with very fine pearlite, which is sometimes in a network formation. A typical example of this is illustrated in Fig. 23. The sample from which this micrograph was taken had the following analysis:—T.C, 3.93 per cent.; Si, 0.88; Mn, 0.30; S, 0.145, and P, 0.03 per cent.

The general structure of the sample consisted of a mixture of medium-sized flake graphite and supercooled graphite in a matrix of pearlite, with a small amount of eutectic cementite. Both manganese and iron sulphides were present. The section of the sample concerned was approximately 2 in. by 2 in. Examination at a high magnification revealed that fine pearlite usually radiated from a very fine band of hypereutectoid cementite (Fig. 24).

This type of structure also occurs to a different degree in whiteheart malleable irons which contain an unusually high sulphur/manganese ratio. In spite of the fact that in these malleable irons the eutectic cementite has broken down, the hypereutectoid cementite, remaining dissolved in the austenite at the annealing temperature, appears to be exceptionally stable, with the result that it is deposited at the grain boundaries in a network formation. Pearlite forming adjacent to this hypereutectoid cementite exists in a very fine form, while that towards the centres of the grains occurs in a very coarse and abnormally divorced form. A typical example of this structure in a whiteheart malleable iron is illustrated in Figs. 25 and 26. Such a structure in malleable iron is always associated with inferior mechanical properties. At the moment it is impossible to tell whether the occurrence of these fine and coarse forms of pearlite is the direct result of the presence of iron sulphide or an indirect result brought about by the stabilising effect of the iron sulphide on the hypo-eutectoid cementite. It is certain, however, that this structural characteristic can be used as a preliminary indication of the presence of iron sulphide in any particular sample and of its tendency to throw a "sulphur chill."

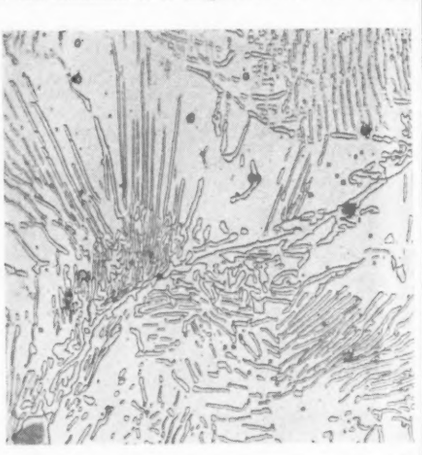


FIG. 26.—AREA OF FINE PEARLITE IN FIG. 25 AT HIGHER MAGNIFICATION. HYPEREUTECTOID CEMENTITE REVEALED. 4-MM. DRY OBJECTIVE. ETCHED IN PICRIC ACID. × 600.

(To be continued.)

REFERENCES.

37 Portevin and Castro: Journ. Iron and Steel Inst., 1935, No. II, p. 237.
39 Norbury: Journ. Iron and Steel Inst., 1939, No. II, p. 161.
39 Allen: Trans. A.F.A., 1931, vol. 39, p. 733.
40 Schwartz: "Metals and Alloys," 1935, vol. 6, p. 328.
41 Schwartz and Junge: Trans. A.F.A., 1934, vol. 42, p. 94.
42 Schwartz: Journ. Iron and Steel Inst., 1938, No. II, p. 253.

Rolled Magnesium Alloys

The tensile properties of binary magnesium alloys is discussed by MR. J. C. MCDONALD in a Paper in "Metals Technology," who concludes that ductility is markedly increased by calcium, cerium, gallium and thorium. The maximum strength is also increased.

Concreting in Cold Weather

In Canada and the northern part of the United States very cold winters are the rule, and the technique which has been evolved there can be applied to work in this country should we have exceptionally hard weather. This subject is dealt with in Wartime Building Bulletin No. 11, issued by the Department of Scientific and Industrial Research, entitled "Precautions for Concreting and Bricklaying in Cold Weather."

Melting Losses in the Coreless Induction Furnace

GERMAN EFFORTS TO CONSERVE ALLOYING ELEMENTS

The growing importance of alloy and high-quality steels, which have steadily been replacing the plain carbon steels, calls for the maximum conservation in the consumption of the alloying elements, especially where, as in the case of Germany, supplies are dependent on imports from overseas countries, now more or less inaccessible. The German steel industry has paid the closest attention to this problem and made much headway in economising these elements by employing inexpensive elements easy to get, in place of the expensive ones which can only be obtained from overseas, as, for instance, in the production of chromium-molybdenum steels in place of the nickel structural steels, and by modifying the composition of alloy steels, especially high-speed steels, to save just those elements difficult to procure. Apart from these economies, mainly in ultimate composition, endeavours have also been made to reduce losses of the valuable elements in the steelworks themselves, as by cutting down melting and oxidation losses to a minimum and recovering alloying elements from slag and waste wherever possible.

This wide subject of economy in alloying elements has been studied by German investigators from many angles, and HELMUT WEITZER, in Report No. 362 of the steelworks committee of the Verein deutscher Eisenhüttenleute, published in "Stahl und Eisen," deals with the matter from the point of view of the melting losses sustained in electric-furnace, and particularly induction-furnace, practice. This author points out that the opportunity of effecting further economies in current practice in basic and acid open-hearth furnaces is limited owing to the peculiar conditions obtaining in these furnaces; the same applies to the acid arc furnace, where conditions are much the same as in the acid open-hearth furnace. This limits consideration of the problem to the basic arc and the coreless induction furnaces. Melting losses, generally, in the basic arc furnace have been studied extensively by Pakulla and Rudnik, who deduced simple percentage expressions for the relative and absolute melting losses, while W. Hessenbruch, from a study of conditions in both acid and basic coreless induction furnaces, showed that the melting losses can be expressed exponentially on the basis of a time constant, a result which has more a theoretical, rather than a practical, value, since the melting time cannot always be adapted to the nature of the charge in hand and a furnace must usually be tapped long before the reactions between the various reactants have arrived at completion.

Fe, C and Mn Losses

It is obvious that the steelworker requires more practical information than mathematical expressions of this character. To provide such information the author therefore collates certain available data obtained under more or less practical conditions, entering more fully into the conditions governing the melting losses in the acid coreless induction furnace, which is extensively used in Germany. In these furnaces, the iron losses are much lower than in the basic arc furnace, where even with charges made up of clean waste as produced in the induction furnace itself, the losses may still average around 3 per cent. In the induction furnace, loss values obtained were 0.85 per cent. with 0.80 per cent. Mn and 1.4 per cent. with 0.20 per cent. Mn. In this case melting losses were determined at two different Mn concentrations to bring out the protective action of the Mn resulting from the higher affinity of Mn for oxygen. The carbon content of the charge did not appear to have a bearing on the magnitude of the iron losses. The higher iron losses in the arc furnace may only be apparent owing to the absence of volatilisation in the induction furnace or owing to the fact that in the arc furnace the exposed surface, which is considerably greater in relation to the depth of the scrap, favours interaction between atmospheric oxygen and the molten scrap, but inhibits attack on the part of the scrap not yet molten. The small loss in the induction furnace results in the difference in weight between the initial charge and the tapped metal being only of the order of 1 per cent.

Investigations of the reactions affecting manganese and carbon losses have shown that with both 0.20 and 0.80 per cent. Mn in the charge the C and Mn losses decrease as the C content rises, a result confirmed by different workers and by the observation that carbon losses practically disappear in charges with 0.80 per cent. Mn. In the case of low-C charges, the Mn losses are reduced as the Si increases, and amount to 5 to 10 per cent. with a charge of 1 to 2 per cent. Mn, 0.1 per cent. C and 1 per cent. Si. Temperature fluctuations have a considerable influence on the Mn losses in these charges.

Chromium and Nickel

The increasing use made of chromium as an alloying element and the disparity in cost between low-C ferro-chrome and high-C ferro-chrome make it desirable to reduce chromium losses and to recover as much Cr from slag, etc., as possible. This is a difficult matter in the arc furnace owing to the carburising action of the electrodes, and it is fortunate, therefore, that Cr losses in the induction furnace are lower than in the arc furnace. Up to about 1 per cent. Cr in the charge, the loss in the induction furnace is practically zero; in some cases the Cr may even rise owing to the relatively greater Fe losses. Conditions are still more favourable using a high-silicon Cr-scrap; thus a maximum loss of 3.5 per cent. was found to be reduced to 1.5 per cent. in the presence of 1 per cent. Si. On the other hand, working up this scrap in the basic arc furnace is not a simple process, for it is difficult to keep the carbon as low as with low-Si scrap and, secondly, some or all the Si is oxidised on melting in the arc furnace and forms Ca silicates with the slag lime, resulting in a very refractory slag on combination with the Cr silicates also produced. This causes a large increase in the Cr losses, as confirmed by observations on the acid open-hearth and arc furnaces, where, owing to accumulation in the slag of very refractory Cr silicates, the melting losses may rise to as high as 15 per cent. irrespective of the initial Cr content. With complex steels, such as high-speed steels, no Cr losses are found even when the Si and Mn are low; in fact, most melts show an increase in Cr.

Nickel losses in the induction furnace are in all cases lower than in the arc furnace, due to the absence of volatilisation in the former; Pakulla has found up to 30 per cent. Ni oxide in the flue dust from arc furnaces. Whether the CO atmosphere in the arc furnace during refining participates in volatilisation has not yet been determined experimentally.

Similar satisfactory conditions rule with cobalt, for which the losses are again very low. Cobalt steels, containing 2.5 to 36 per cent. Co melted in the usual way, showed losses which were less than 2 per cent. of the weight of the metal. In the basic arc furnace Pakulla found a loss of 23 kg. of Co per ton, while the induction furnace gave only 15 kg. per ton.

Tungsten and Vanadium

Tungsten melting losses have been determined by adding the metal in the form of scrap of known composition or as ferro-tungsten; in the case of low-alloy tool steels, the losses were an average of 5.6 per cent. As the tungsten in the charge is increased, the losses diminish to below 1 per cent., at which they remain constant. Molybdenum, being so readily volatile, was added to the experimental melts only after complete fusion of the charge, either as ferro-molybdenum or virgin metal. The Mo in the scrap used did not seem to volatilise easily, since the Mo losses with these materials appeared to be practically constant. In many cases, the Mo content seemed to increase owing to the high iron melting losses and the relatively low quantity of Mo lost. With 0.30 per cent. Mo in the charge, the concentration of Mo was apparently constant, but losses increasing linearly with Mo concentration are obtained at higher Mo values, attaining a value of 9.1 per cent. at 20 per cent. Mo. With high-speed steels, an increase of about 1 per cent. in Mo was found, which may be due merely to a displacement in the Fe value by the 25 per cent. of other alloying elements, *viz.*, Cr, W and V; the precise cause of this is still obscure.

Vanadium added to induction furnace charges either as scrap metal, Norwegian vanadium pig-iron or 50 to 80 per cent. ferro-vanadium, the latter sometimes not being added until the charge was completely molten, showed that irrespective of which raw material was used, melting losses were almost constant. The same result was obtained whether charges were merely remelted or were being worked-up, although the values obtained were somewhat scattered. In the basic arc furnace, the losses were different according as the charge was merely remelted or being worked to a required composition. About 20 per cent. of the V in the scrap is oxidised and cannot be reduced in the bath, in spite of the final slag having the correct composition. Reduction with ferro-silicon cannot be adopted without affecting the purity of the steel.

Tantalum, Niobium and Zirconium

Tantalum and niobium were added to charges immediately on fusion as 60 to 80 per cent. ferro-alloy. The primary charge in these investigations consisted of an austenitic Cr-Ni steel (18-8). The average losses in the induction furnace were 5 per cent., and in the basic arc furnace 4.14 per cent. In the basic furnace, on the other hand, using a non-oxidising slag and adding the correct quantity of Si, the relative loss of tantalum and niobium was about 21 per cent., although these metals were only added 10 min. before the charge was tapped.

The zirconium losses were determined by adding 0.50 per cent. Zr as Zr-Si containing 48.5 per cent. Zr, to an acid induction furnace just before tapping; the melting losses were 62 per cent. In the basic arc furnace, Zr-Si of this composition cannot be brought to alloy, but on adding to the ladle gave a loss of 25 per cent. Similarly, a titanium alloy with 38 per cent. Ti and 2.8 per cent. Al was added to a charge in the acid induction furnace to make up 0.5 per cent. of the charge. The melting loss was here 26.5 per cent., but was 50 per cent. in the basic arc furnace when the alloy was added direct, and even 20 per cent. when added to the ladle.

Melting losses in the basic induction furnace are of the same order as in the acid induction

(*Continued on page* 66.)

Strain-Ageing and Yield-Point Characteristics of Low-Carbon Steels

INFLUENCE OF SOME SPECIAL ELEMENTS

In a Paper on "The Influence of Some Special Elements upon the Strain-Ageing and Yield-Point Characteristics of Low-Carbon Steels," which PRINCIPAL C. A. EDWARDS, D.Sc., F.R.S., D. L. PHILLIPS, M.Sc., and H. N. JONES, M.Sc. (University College of Swansea), presented at a recent meeting of the Iron and Steel Institute, there is much data of interest to vitreous enamellers. The authors discuss the results of their experiments in the following statement.

Two Groups of Elements

The elements of which the influence upon the strain-age-hardening qualities of low-carbon steels has been studied can be very conveniently divided into two more or less distinct groups. The first of these includes aluminium, copper and nickel, which do not enter into chemical combination with carbon when they are present in steel. All samples in this group show unmistakable signs of age-hardening after straining, and there is a tendency for the degree of this hardening to become more evident as the percentage of the element present increases. The results obtained with samples which fall within this group do not call for any special comment.

The elements falling within the second group are those which are known to combine with carbon. The extent to which this combination proceeds when the elements are individually present in steel varies considerably. The following elements belonging to the second group have been examined in the present investigation: Molybdenum, manganese, chromium, vanadium, niobium and titanium. This order is in accordance with the recognised affinity with which the elements combine with carbon when present in steel. Before proceeding to discuss the influence of these elements on strain-age-hardening, it may be useful to make the following observations.

For a long time it has been recognised that carbon may be at least partly responsible for the increased hardness which develops on ageing previously strained mild steel. Thus, Pfeil has shown that mild steel from which all the carbon has been removed, provided that the oxygen has also been reduced to something approaching zero, does not possess any strain-age-hardening qualities. So far as the carbon is concerned, Pfeil concluded that the age-hardening for which this element is responsible is due to the fact that that carbon which is dissolved in the ferrite at the ordinary temperature, about 0.007 per cent., is partly precipitated as a result of the straining and ageing. Thus, he considered the phenomenon to be a form of what is generally described as "precipitation-hardening."

On the other hand, Andrew, who also considers strain-age-hardening to be due to carbon, has put forward a more complex explanation of the possible function of carbon. Quite briefly, it may be stated that Andrew's conception is that straining causes some of the undissolved carbide of iron to go into solution, that this solid solution is decomposed on ageing after straining, and that precipitation-hardening thus takes place. The authors feel they can accept this explanation if it can be proved that small amounts of cold-work give rise to an increased quantity of carbide of iron being taken into solid solution by iron. For the moment the outstanding fact is that carbon is one of the elements which will cause mild steel to strain-age-harden.

At an early stage in this work it was expected that one of the elements used would have such a strong affinity for carbon that, when present in sufficient quantity in a low-carbon steel, it would prevent the formation of carbide of iron and give a special carbide which might also be insoluble in ferrite; such a steel would not show any tendency to strain-age-harden because there would be no possibility of carbon precipitation.

Yield-Point Phenomenon

Kuroda has put forward the view that the well-known yield-point phenomenon, which is peculiarly characteristic of mild steel, is not an intrinsic property of iron itself, but is due to the enrichment of carbon, or other elements, at the boundaries of the ferrite crystals. His view is that this film of, say, strong cementite supports the load during a tensile test to an extent which is well beyond the capacity of the ferrite grains themselves, and, therefore, once the stress gets beyond that at which these films are broken, the whole stress is thrown upon the interior of the ferrite crystals, and a pronounced amount of plastic deformation takes place without further increase in the applied stress. Hence, any treatment which removes this film will cause the yield-point phenomenon to disappear. Kuroda describes a number of experiments which he carried out with a view to testing his ideas, and many of the results support his views.

Previously it had been generally accepted that the reinforcing effects of the crystal boundaries, which give rise to the well-known yield-point characteristics, were due to the natural properties of the metal itself, and in no way due to the presence of a foreign element.

In the light of previous work it was recognised that difficulty might be experienced in obtaining reliable evidence to test Kuroda's ideas. For example, even if it is assumed that the yield point is caused by the presence of carbon, it is known that the quantity of carbon need only be quite small. Thus, in their recent work, Edwards, Jones and Walters found that well-developed yield points were observed in material containing no more than 0.02 per cent. of carbon. Further, they found that the intensity of the yield point could be changed by varying the crystal size. In other words, it could be diminished by increasing, and intensified by decreasing, the crystal size, by modifying the heat-treatment of a given material. The yield point was shown to fade to almost zero in a steel with 0.02 per cent. of carbon in specimens containing rather large crystals. These facts indicate how difficult it may be to decide to what extent the disappearance of the yield point is due to the absence of carbon or the form in which it is present on the one hand, or to the presence of large crystals on the other.

It was for these reasons that the authors hoped to select an element which would completely combine with the carbon present and form a carbide which would be almost, if not completely, insoluble in ferrite. Under these conditions no film of carbide of iron at the crystal boundaries, such as that postulated by Kuroda, could be formed. In any case, if these conditions could be satisfied and no yield point was revealed on a stress-strain diagram of such a specimen, then it would be a step in support of Kuroda's suggestion as to the fundamental cause of the well-known yield point in mild steel.

Strain-Age-Hardening

Turning, however, to the problem of strain-age-hardening, it will be found on reference to the tabulated results obtained for those elements which form carbides that they all show unmistakable indications of diminishing the degree of strain-age-hardening as the percentage of the element increases. This can be more clearly observed by examining the data dealing with the effects of the elements upon the ultimate breaking stresses; an approximate idea of the comparative quantitative influence of the various elements can be gained from the following figures, which include experimental results taken from the tabulated data given in the Paper:—

Element.	Amount present. Per cent.	Rise in ultimate breaking stress after straining 6 per cent. and ageing. Tons per sq. in.
Molybdenum ..	2.0	3.27
Manganese ..	2.0	1.80
Chromium ..	1.15	0.82
Vanadium ..	0.55	0.02
Niobium	0.36	Nil
Titanium ..	0.21	Nil

In making comparisons of this kind the authors believe it is more reliable to consider the ultimate-stress results, as distinct from the yield-point values. The chief reason for this view is that the recorded values for the rise in the yield point as a result of strain-age-hardening are subject to greater experimental error than the corresponding ultimate-stress figures.

Whilst the authors appreciate the significance of Kuroda's views concerning the cause of the yield point in mild steel, they think that more definite evidence is needed before they can be accepted in their present form. The presence of a film such as he suggests has still to be proved. Further, it is necessary to demonstrate that a steel containing less carbon than is capable of being held in solid solution by ferrite will not show a yield point on the stress-strain diagram.

Authors' Concepts

Before this aspect of the problem can be solved, much more exacting and carefully planned experiments will have to be made than have hitherto been carried out. Nevertheless, with comparatively small changes in Kuroda's conception, all its advantages might be retained without considering the presence of such a film. It is with these possibilities in mind that the authors, quite tentatively, put forward the following observations for future consideration:

(1) Carbon dissolved in ferrite will cause strain-age-hardening, and this is due to what is generally regarded as a special kind of precipitation of the carbon.

(2) This precipitation can be considered as something in the nature of a stage between a perfect solution and the separation of carbide of iron in the form of a distinct phase.

(3) The internal stresses set up in this way distort the crystal space-lattice and thus cause the material to be harder than it was before ageing.

It may then be presumed that the extra resistance to plastic flow of the crystal boundaries, which gives rise to the yield point in ordinary ferrite, is due to the normal distortion associated with a change of orientation being accentuated by the presence of semi-precipitated carbide of iron in these regions. In other words, though the carbon content may be less than the accepted solubility limit in ferrite, the state of this carbon near the crystal boundaries may be much the same as that which prevails within the body of such crystals after straining and ageing. This is merely suggesting that the interatomic stresses near the crystal boundaries are such as

STANTON-DALE

Refined

PIG IRON

IS CHARACTERISED by closeness of grain structure, uniformity of composition and fine graphitic carbon evenly distributed.

IS PRODUCED to guaranteed analysis in seven standard grades.

CAN BE MADE to customers' individual requirements with total carbon from 2·6 per cent. upwards.

SHOULD BE USED to tone up high phosphorus irons and scrap, to replace Hematite, and to produce castings for all high duty purposes.

Users are invited to avail themselves of the Stanton Technical Service which offers free expert advice on special mixtures and other Foundry problems.

THE STANTON IRONWORKS COMPANY LIMITED, NEAR NOTTINGHAM

to cause the carbide to be in a condition of semi-precipitation in these regions in annealed specimens. Some of the important facts which should be remembered in this connection are:

(1) Pfeil has shown that mild steel from which the whole of the carbon has been removed does not display any capacity to strain-age-harden.

(2) He found that this kind of hardening takes place when the carbon content is not more than 0.003 per cent., *i.e.*, less than can be held in solid solution by ferrite at the ordinary atmospheric temperature.

(3) It has been found that annealed steel from which all the carbon has been removed does not show a yield point.

Position Summarised

In the light of these facts and the evidence which has been revealed in the present investigation concerning the influence of titanium and other carbide-forming elements in causing steel to become non-strain-age-hardening and in eliminating the yield point, the problems under review become much clearer. The position may be briefly summarised, as follows:

(*a*) The presence of small percentages of carbon, when associated with iron (*i.e.*, not in combination with some other element), will give rise to strain-age-hardening.

(*b*) The yield point, a characteristic of ordinary mild steel, is not an intrinsic property of iron itself, but is due to the presence of carbon.

(*c*) The effects of carbon, as regards both its influence upon strain-age-hardening of mild steel and upon the yield point, can be completely neutralised by the addition of elements for which carbon has a greater chemical affinity than it has for iron.

(*d*) The function of titanium and other carbide-forming elements, when introduced into steel in sufficient quantity, is to combine with the whole of the carbon present, leaving none to be directly associated with the iron. The authors believe that these special carbides are either insoluble in ferrite or incapable of being precipitated as a result of straining and subsequent ageing; in any case, there is no carbide precipitation as a result of straining and ageing and, therefore, no hardening can be produced by this treatment. Further, if no carbon is dissolved in the ferrite, there can be no special distortion of the space-lattice at and near the crystal boundaries. Therefore the material behaves like most other pure metals and non-ferrous alloys, namely, no yield point is observed on a tensile stress-strain diagram.

(*e*) It is recognised that other elements besides carbon may have the power of imparting strain-age-hardening qualities to mild steel, and the same may be found to be the case for the yield point.

(*f*) In conclusion, it is perhaps necessary to mention that no detailed consideration has been given in the present work to the possible influence of oxygen and nitrogen. The authors recognise that interesting and important results may be obtained by extending the study to these two elements, and they look forward to the possibility of doing this. Nevertheless, they do not think the results will necessitate any material modification in the conclusions which have been arrived at in the present Paper. It is true that most of the carbide-forming elements that have been considered also possess a strong affinity for oxygen, and many of them are believed to be capable of combining with, and possibly of removing, any nitrogen that may be present in liquid steel. That being so, the question arises whether the effects of these special carbide-forming elements are entirely due to their combining with carbon or also to their removal of, or combination with, oxygen and nitrogen.

The authors believe that the answer is provided by the results obtained with two of the

(*Continued in next column.*)

Gases in Steel

"Gases in Steel" was the subject of a recent lecture by DR. BENGT KJERRMAN, director of the S.K.F. Ball Bearing Company's central laboratory in Göteborg, where for several years past comprehensive research work has been carried on in respect of properties and conditions which determine the quality of the steel. Dr. Kjerrman pointed out that the greater part of the gases in molten steel are given off when the steel cools, while the residuum is in general combined to form oxides or silicates, but there is also to some extent free gas in the solid steel. All gases are not visible as non-metallic inclusion when the steel is examined microscopically, and it was with the object of enabling the quality of different steels to be classified and judged, in spite of this deficiency, that research was instituted.

Two main methods are used. One aims at the determination of the total amount of oxygen in steel were made as early as in 1882. In spite of all improvements in analytical methods since that time, the work is still most time-consuming. It takes no less than a year for a man to make 35 analyses of the oxygen, hydrogen and nitrogen, silica and alumina contents. Indicating another example of the difficulties connected with the work, Dr. Kjerrman mentioned that in 1935 the U.S. Bureau of Standards sent eight similar samples of steel to laboratories in different parts of the world, including the Metallographic Institute in Stockholm. The samples were accompanied by a request to determine the content of gases, and in particular that of oxygen, and the recipients were allowed to use any method they wished. The results showed variations of the widest character.

So far as Sweden is concerned it is a question, if possible, to show what "the body" in Swedish steel really is. It is often conceded from practical tests of finished ball bearings, for example, said the lecturer, that Swedish steel is superior to electric steel from other sources for such use, as also for other special purposes. It has not been possible, however, to prove scientifically to what this superiority is due, but Dr. Kjerrman hoped that gas determinations would throw light on this question.

(*Continued from previous column.*)

titanium steels: The steel containing 0.02 per cent. carbon and 0.2 per cent. titanium had no yield point and did not strain-age-harden, but the specimen containing 0.085 per cent. of carbon displayed both these qualities to an extent which was comparable with steel containing no titanium. It seems reasonable to conclude that the absence of the yield point and strain-age-hardening in the former case cannot be attributed to the removal of oxygen and nitrogen, because it seems most probable that both these elements would be just as completely removed in the second sample as in the first. In other words, simply by raising the carbon content, the yield point and strain-age-hardening were made to reappear.

The only uncertain factor in this line of reasoning is the question whether the higher carbon content reduces the opportunity for titanium to combine with nitrogen. The question of oxygen is not so important in this connection, since it has been shown that samples with appreciable quantities of aluminium display normal strain-age-hardening, and they also show the ordinary yield point.

Welding and Flame-Cutting Wrought Iron

The precautions necessary to ensure successful welding and flame-cutting of wrought iron are outlined by MR. HAROLD LAWRENCE in an article published in "Steel."

The author points out that wrought iron, like most ferrous metals, is readily welded and flame-cut provided certain precautions are observed. To understand these factors, some discussion of the nature of wrought iron is warranted. Primarily, wrought iron is used for its better resistance to corrosion resulting from its peculiar structure—largely an iron silicate or slag varying from 1 to 3½ per cent. of the metal present. This slag is distributed by the rolling operation into a series of threads. As many as 250,000 such slag stringers may be found in a cross-sectional square inch. It is these slag stringers that impart to wrought iron its resistance to corrosion since any corrosion soon meets the slag inclusions that set up barriers to the further spread of corrosive attack. Since there are so many slag stringers present throughout the metal, corrosion attack is impeded at every turn.

Welding Technique

In welding, however, these slag stringers present two distinct problems. First, the slag must be floated out of the weld metal. Second, the greasy appearance presented by the lower melting point of the silicates must not be confused with the slick appearance of the steel at the fusion temperature in oxy-acetylene welding.

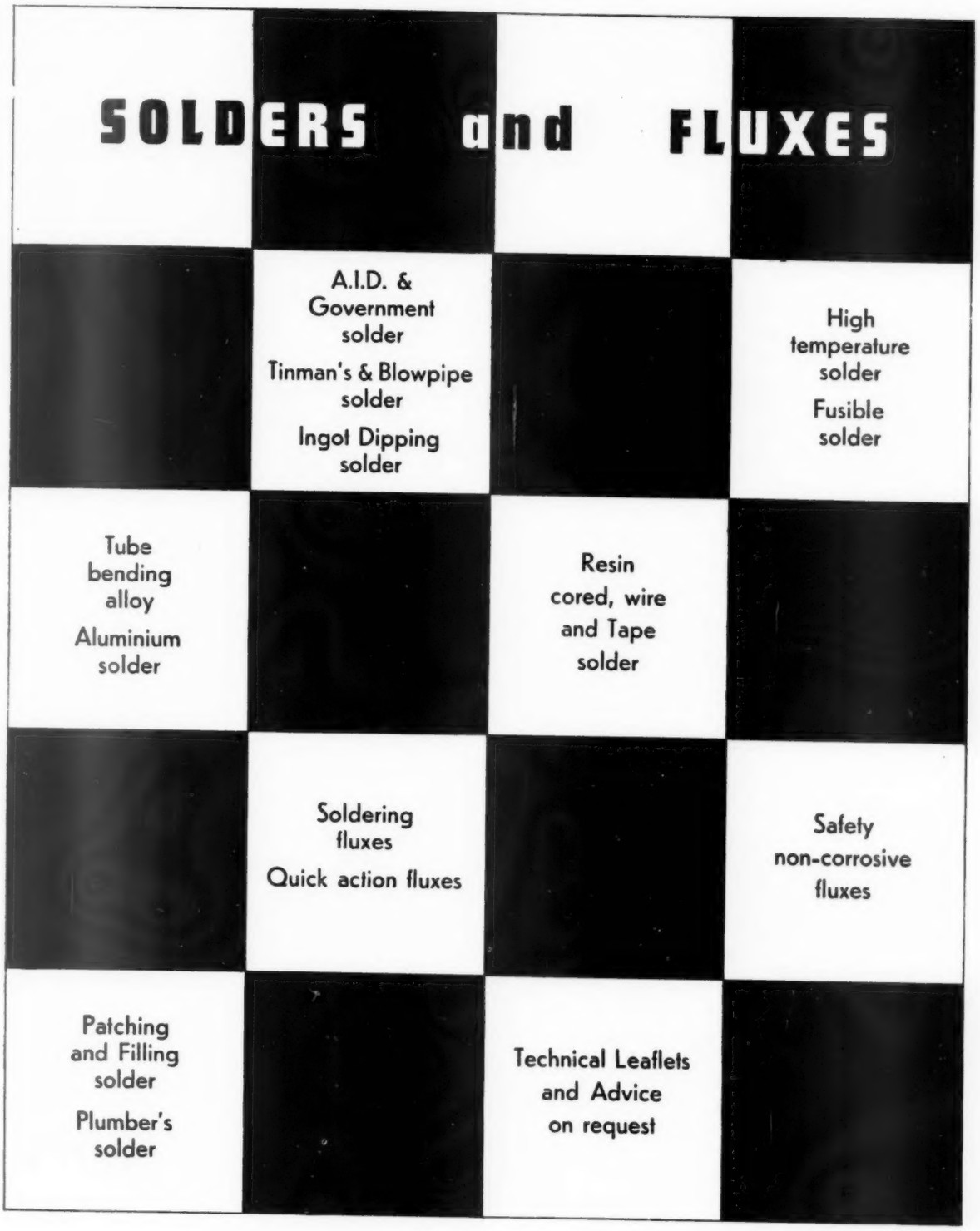
Wrought iron is essentially a very low-carbon steel. Therefore, it is non-hardening and quite ductile. These factors eliminate the usual problems of a hardened heat-affected zone and excessive internal stresses. Not all the locked-up stresses are dissipated in heavy sections, though, and for this reason stress relieving of welds in thick plate remains good practice. Usual stress-relieving temperatures may be lowered to 700 or 800 deg. F. and will bring about the same results as 1,150 or 1,250 deg. F. for steel.

In metallic arc welding wrought iron, a lower heat or wattage is required to go hand in hand with a slower speed of travel.

Electrode choice is of extreme importance. Where butt and fillet welds are made in wrought iron of less than ⅜ in. thickness, the lower heat capacity of the material must be taken into consideration. Butt welds are best made with all-position electrodes while fillet welds may either be deposited with this type electrode or with mineral-coated downhand rod. Wrought iron of more than ⅜ in. thickness works well with electrodes used for mild steel of the same thickness except general-purpose electrodes for stringer bead fillet welds. The all-position and downhand types will generally be found best.

Slow Speeds in Flame-Cutting

Flame-cutting wrought iron is different from cutting steel because the presence of the iron silicate stringers profoundly affects the cutting operation. Almost everyone working with flame-cutting is familiar with the effect of a plate lamination on the cut. A bad lamination will cause the operator to lose his cut altogether. When a bad lamination is replaced by a multiplicity of minute slag inclusions, the effect is somewhat the same. Slow speeds with considerable preheat will bring about the ready severing of wrought iron. Because of the refractoriness of the inclusions, oxygen combustion efficiency is lowered somewhat. Reaction may be slowed, also. Lowering the oxygen pressures will furnish enough oxygen to burn and erode without an excessive stream pressure and will give sufficient speed for economical cutting.



FRY'S are specialists in the manufacture of all types of solder and flux for government and civil work and are willing to advise on any soldering problems or difficulties.

FRY'S METAL FOUNDRIES LTD

TANDEM WORKS · MERTON ABBEY · LONDON · S·W·19

Telephone : MITcham 4023

(17)

The Week's News in Brief

Trade Talk

THE PRICE of Portland and rapid-hardening Portland cement has been advanced by 5s. per ton.

JARROW-ON-TYNE TOWN COUNCIL is to approach the Government again on the question of restarting the former Palmers' Shipyard.

THE BRITISH STANDARDS INSTITUTION have issued two new specifications covering naval brass die-castings (B.S. 920) and brass gravity die-castings (B.S. 932).

TO EXPORT dairy machinery to any destination, a licence from the Board of Trade will now be required, under the terms of the Export of Goods (Control) (No. 3) Order, 1941, which comes into force to-day (Thursday).

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED, Springburn, Glasgow, have received orders for 62 locomotives (2—8—0 class) and tenders for the London Midland & Scottish Railway Company. The firm have also booked an order for a locomotive for Newfoundland.

THE BRITISH EMPIRE MEDAL for meritorious service has been awarded to the following:—William Brown, fitter, Heavy Gun Mountings Department, Vickers-Armstrongs, Limited, Elswick; George Charles Minhinnick, Vickers-Armstrongs, Limited, Barrow-in-Furness; Hugh Muir, under-foreman fitter, Beardmores, Parkhead; Arthur Nelson, assistant works manager, Vickers-Armstrongs Supermarine Works; Herbert Heron Renshaw, forgeman, English Steel Corporation, Limited.

THE MINISTER OF SUPPLY has appointed Mr. F. W. Bain to be chairman of the Chemical Control Board. This Board will deal with questions relating to the control and development of supplies of the chemicals falling within the scope of the Raw Materials Department of the Ministry of Supply. The Board will consist of the Controllers of the various chemicals and of other persons whose services may from time to time be available for the consideration of particular problems with which they are concerned. Mr. Bain has been associated with Imperial Chemical Industries, Limited, since the company's formation, and was made a director about a year ago.

THE Commissioners of Inland Revenue and the Board of Referees have decided that war conditions and especially the disorganisation of offices by air raids justify a general extension of the time-limit to March 31 next for taxpayers to apply for a reasonable substituted standard of profits in connection with Excess Profits Tax. It will be open to the Commissioners and the Board, in further exercise of their discretion, to grant extensions of time beyond that date for good cause in individual cases. It is pointed out that under the provisions of the Finance Act, 1940, a taxpayer who made losses or low profits in the standard years may apply for a reasonable substituted standard of profits, but notice of such application was required to be given before the end of 1940.

Reports and Dividends

British Piston Ring Company, Limited—Interim dividend of 5 per cent. on the ordinary shares.

Electrolytic Zinc Company of Australasia, Limited—Interim dividend of 6 per cent.

T. M. Birkett & Sons, Limited—The directors have decided not to pay an interim dividend "for the time being."

International Combustion, Limited—Final dividend of 15 per cent., together with a cash bonus of 10 per cent., making a total distribution of 30 per cent. for the year ended September 30 last.

Henry Meadows, Limited—Net profit to August 31 last, after tax, £53,736; brought in, £10,011; to obsolescence, £6,276; contingencies reserve, £15,000; final dividend of 17½ per cent., making 25 per cent.; carried forward, £11,772.

Westinghouse Brake & Signal Company, Limited—Net profit for the year to September 30, £159,781; brought in, £90,432; to general reserve, £50,000; staff pension account, £5,000; to reserve for contingencies, £25,000; to reserve for investments, £13,293; dividend of 10 per cent.; carried forward, £92,384.

Personal

MR. W. A. AKERS and Mr. W. F. Lutyens have been appointed additional directors of Imperial Chemical Industries, Limited.

MR. REGINALD J. CREWS has been appointed secretary to the Blaenavon Company, Limited. He will take up his duties at Blaenavon at the beginning of next month.

MR. L. P. B. MERRIAM, who is managing director of B.X. Plastics, Limited, and a director of British Xylonite Company, Limited, has been appointed by the Minister of Supply as Controller of Plastics.

MR. T. F. A. BOARD has been appointed Controller of Molasses and Industrial Alcohol by the Minister of Supply. Mr. Board is chairman of John Watney & Company, Limited (a subsidiary of Booth's Distilleries).

SIR CECIL BUDD, at the invitation of the directors, has agreed to rejoin the board of the Imperial Smelting Corporation, Limited, to fill the vacancy arising from the appointment of Capt. Oliver Lyttelton, M.P., as President of the Board of Trade. Mr. L. B. Robinson has been appointed a joint managing director of the corporation. Sir Cecil Budd has been elected also to the boards of the Zinc Corporation, Limited, and New Broken Hill Consolidated, Limited.

Wills

SCHUSTER, L. W., of Hale, Cheshire, research engineer £34,170

SIMS, P. J., for 27 years Scottish branch manager of the General Electric Company, Limited £21,161

Obituary

DR. D. ROBERTSON, Professor of Electrical Engineering at Bristol University since 1902, died on January 8, aged 65.

VISCOUNT WAKEFIELD, head of C. C. Wakefield & Company, Limited, the oil refiners, has died at Beaconsfield, Bucks, at the age of 81.

MR. RUPERT SIDNEY MELLOR, formerly for 40 years joint proprietor of the Ribble Foundry at Preston, has died, aged 93 years of age.

MRS. MARGARET BLAKEY, for many years connected with Pilling's Foundry, Colne, has died. Her father, Mr. John Pilling, was founder of the business.

MR. JAMES BROWN, C.B.E., managing director and deputy chairman of Scott's Shipbuilding & Engineering Company, Limited, of Greenock, has died at the age of 79 years.

SIR LUKE THOMPSON, former M.P. for Sunderland and head of John Thompson & Sons, Limited, coal merchants, Sunderland, died on January 15 as the result of an accident. He was 73 years of age.

MR. EDWARD BRIERLEY, governing director of Edward Brierley & Sons, Limited, scrap and metal merchants, of Blackburn, has died. He founded the company many years ago after being associated with his father, Mr. Samuel Brierley, in a foundry business.

THE DEATH HAS OCCURRED in Aberdeen of Mr. John A. Sangster, at the age of 76. A native of the city, Mr. Sangster was managing director of John A. Sangster, Limited, stone-dressing machinery and crane makers, of St. Clair Engineering Works, Pittodrie Street.

MR. HENRY BERNARD STEWARD, of Coseley, who died on Saturday last, had been associated with the Cannon Iron Foundries, Limited, Deepfields, Bilston, for 51 years. He succeeded his father, who died eight years ago, as chief enamelling chemist, and last year in appreciation of his 50 years with the firm he received a gift from the directors of the company.

WE REGRET to record the death of Mr. William R. Wilson, a director of E. Wilson & Company (Collingwood), Limited, engineers and ironfounders, of Collingwood Street, Liverpool, 3. Mr. Wilson was amongst the oldest members of the Institute of British Foundrymen, having joined on its formation in 1904. He was a member of the Lancashire Branch, but the distance from Manchester precluded his regular participation in the affairs of the Branch. Nevertheless, he always retained a lively interest in its activities.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Eric Bemrose (Engineers), Limited, Long Lane, Liverpool, 9—Capital, £1,000.

Henry Caton (Engineers), Limited—Capital, £1,000. Subscriber: H. F. P. Caton, 77, Kenilworth Road, Coventry.

Whitlock, Bros., Limited, Great Yeldham, Essex—Capital, £20,000. Agricultural and general engineers, etc. Permanent directors: T. S., H. W., and A. C. Whitlock.

Champion (Scissors), Limited, Champion Works, Petre Street, Sheffield, 4—Capital, £15,000. Manufacturers of scissors, etc. Directors: R. L. Walsh and W. L. Jollie.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal":—

"NEVEN"—Abrasive tools. IMPREGNATED DIAMOND PRODUCTS, LIMITED, 6-7, Kingston Buildings, Bath.

"STEIN DIMAG," "STEIN DIKRO" and "STEIN KM"—Refractory bricks. JOHN G. STEIN & COMPANY, LIMITED, Bonnybridge, Stirlingshire.

"G.A." (Circular Device)—Metal ventilators. GREENWOOD'S & AIRVAC VENTILATING COMPANY, LIMITED, 270, Abbeydale Road, North Circular Road, Wembley.

"BRYTAL"—Medical instruments and apparatus, installations for heating, cooking, etc.—BRITISH ALUMINIUM COMPANY, LIMITED, Adelaide House, King William Street, London, E.C.4.

The Production of High-Silicon Acid-Resisting Castings

(*Continued from page* 51.)

grinding wheel, either flexible or fixed according to the nature of the work.

Machining

The metal is so hard that it is not practicable to machine the castings and grinding is the only method that can be used. By the adaptation of lathes, vertical boring mills, planing machines, etc., some very fine grinding work can be done. No holes can be drilled in the metal. All bolt holes, etc., have to be cast in.

Patternmaking.—Double contraction allowance must be made in construction of patterns and coreboxes.

Forthcoming Events

JANUARY 25.

Manchester Association of Engineers:—"Recent Engineering Applications of Non-Ferrous Metals and Alloys," Paper by F. Hudson, in Manchester, at 2.30 p.m.

Sheffield Society of Engineers and Metallurgists:—"Special and Alloy Steels," Presidential address by Dr. W. H. Hatfield, in Sheffield, at 2.30 p.m.

JANUARY 27.

Royal Society of Arts:—"Influence of Art on Instruments of War," the second of three Cantor Lectures by James G. Mann, in London, at 1.45 p.m.

FEBRUARY 1.

Institution of Mechanical Engineers (North-Western Branch):—"Power and Combustion," Thomas Hawksley Lecture by Prof. A. C. G. Egerton, in Manchester, at 2.30 p.m.

Institute of British Foundrymen

JANUARY 25.

East Midlands Branch:—"Coreshop Production Costs," Paper by N. P. Newman, at Derby.

Middlesbrough Branch:—"Production of Engineering Castings in the Light-Castings Industry," Paper by T. Tyrie, at Middlesbrough, at 3 p.m.

JANUARY 31.

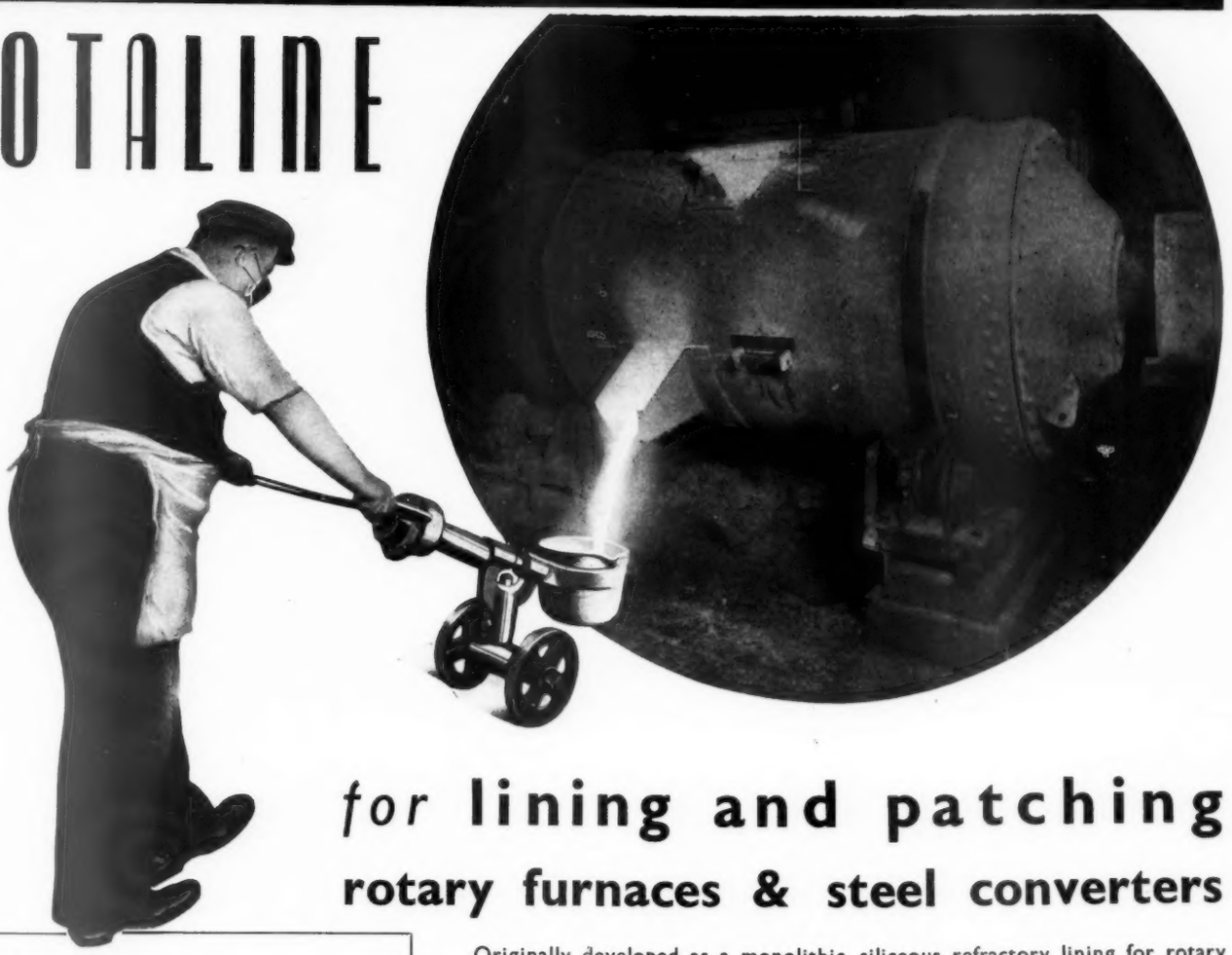
Falkirk Section:—Joint meeting with the Institute of Vitreous Enamellers, at Falkirk, at 7 p.m.

FEBRUARY 1.

Lancashire Branch:—Annual dinner, in Manchester.

LONGER LIFE FROM FURNACE LININGS

ROTALINE



for lining and patching
rotary furnaces & steel converters

There are four grades:

ROTALINE: For rotary furnaces melting grey iron, malleable iron and steel. Stock and Tropenas type converters, hearths of receivers, melting furnaces, etc.

ROTALINE 04: For rotary furnaces melting brass, gunmetal, phosphor-bronze, etc.

ROTALINE PATCH: A finely ground patching composition for patching Rotaline and 04 linings.

ROTALINE D.R: For rotary and semi-rotary electric furnaces, melting iron and steel.

Originally developed as a monolithic siliceous refractory lining for rotary furnaces, Rotaline is also widely used as an efficient lining in steel converters, electric rotary furnaces, and for the hearths of receivers and melting furnaces in the ferrous and non-ferrous industries.

Strict attention is given to grading, volume stability and refractoriness, and these are carefully controlled during the process of manufacture, to ensure a product of constant uniform quality. Rotaline is supplied ready for ramming or patching and no mixing or treatment is necessary before use. Full details will be sent on request.

ROTALINE
MONOLITHIC SILICEOUS REFRACTORY

GENERAL REFRACTORIES LTD.

HEAD OFFICE: GENEFAX HOUSE, SHEFFIELD, 10. TELEPHONE 31113 (6 LINES)

G.P.9.

FIREBRICKS: *Glenboig Special, Glenboig Special Crown, Glenboig, Glenboig Crown, Castlecary, Dykehead, Gem, White Carr, Stour, Hycone, Alumantine, Hysilyn, Adamantine, Llangennech.*
BASIC BRICKS: *Spinella, Saxpyre, Supermag, Diazite, Dolomax.*
ACID-PROOF REFRACTORIES: *Obsidianite, Lasol.*

INSULATION: *Amberlite* Bricks, Cement and Concrete.
SILICA BRICKS: *Lowood, Meltham, Allen, Quartex.*
CEMENTS: *Sintex, Durax, Pyrolyte.* PLASTICS: *Durax, Rotaline, Plastic K-N., Glendoline, Ground Ganister.*
SILLIMANITE: Tank Blocks, Bricks and Cements.
SANDS: Moulding, Brick Facing, Silica, Glass.

Raw Material Markets

Many foundries are continuing to make extensive use of scrap material and pig-iron produced from home ores, thus relieving the pressure on low-phosphorus iron and hematite, outputs of which are fully booked for essential work. Steelworks, too, have been able to rearrange their mixtures, so that scrap can be used in larger tonnages to the exclusion of iron made from imported ores. Distribution of all descriptions of iron is, of course, controlled, but the authorities are ensuring a steady flow of deliveries to works engaged on Government contracts. Heavy engineering foundries fall into this category, but more and more makers of light castings are receiving work of national importance and demand for iron from this trade continues to increase.

Pig-Iron

MIDDLESBROUGH—Some of the local light foundries have been able to accumulate small reserve stocks of iron, and these concerns are experiencing little difficulty in obtaining their full requirements from producers in the Midlands. With more reconstruction work coming to hand, these foundries are better employed than for some time past, and there is every indication that stronger conditions will prevail in the future. It is fortunate that supplies of Midlands iron are forthcoming satisfactorily, as the output of Cleveland foundry iron remains negligible. Very active operations are being carried on among the heavy engineers here, Government contracts being sufficient to ensure full-time working.

Consumers of hematite are still finding it difficult to procure all the material that they would wish to have on hand, and many furnaces are changing their mixtures, so that less reliance is now placed upon hematite than was formerly the case. Although such measures can only be adopted in certain instances, the results have been extremely satisfactory. The Control authorities are confining the distribution of hematite to essential users, who, in addition to receiving home-produced iron, are also being supplied with a certain amount of imported material, for which no extra charge is invoiced, despite the considerable difference in price paid by the Control; the balance is, of course, covered by the central fund which was set up to finance the purchase of foreign material.

LANCASHIRE—Consumers of foundry pig-iron in this area are exerting considerable pressure on producers, and the volume of iron railed from Derbyshire and Northamptonshire furnaces represents a substantial tonnage in the aggregate. Most speciality and general engineering concerns are working to capacity, but the position of many jobbing foundries still leaves much to be desired, while light-castings makers, on the whole, are no more than moderately employed. Ironmakers, generally speaking, are despatching adequate tonnages, but there are instances of accumulations of orders. Little improvement is noticeable in the flow of hematite into this county, and the available supply is considerably below actual requirements. Foundries on work of national importance are well cared for, however.

MIDLANDS—Government departments calls on the products of heavy engineers remain very strong, and there is little likelihood of there being any material change in this position, as replacement orders are freely available and no works is allowed to fall below maximum production unless repairs become imperative. Low-phosphorus iron and hematite are the main requirements of these establishments, both of which incur the use of imported ores, which are naturally less freely available than ores found in the United Kingdom. Nevertheless, priority users are not being handicapped, although other classes of consumers are not receiving all they need. A certain amount of high-phosphorus iron is being incorporated in the mixtures of heavy engineers where this is possible, with satisfactory results. Thus, the call for supplies of this type of iron has increased materially of late, as the light-castings trade also is better placed for work and is taking up much larger supplies both on current account and also for building up stocks, which is now permitted by the Control so long as the supply of regular tonnages is not adversely affected.

SCOTLAND—Only with the assistance of imported iron can the full requirements of consumers be met, but works engaged on priority contracts are not in any way handicapped. Shipbuilders and other interests are making insistent demands on the resources of heavy engineering concerns. Trade among the light-castings firms in the Falkirk district is still not brisk, although much better conditions are now reported by most manufacturers. Steelmaking irons are, of course, fully accounted for, works operating at capacity levels.

Coke

Supplies of foundry coke are leaving the ovens quite freely, but some delay is at times encountered *en route*. In spite of transit difficulties, consumers are not inconvenienced, as most of them have considerable ground stocks. Users continue to buy steadily and the introduction of higher prices does not appear to have interrupted normal trade. For delivery to Birmingham and Black Country stations, the current quotation for Durham best foundry coke is 61s. 6d. per ton.

Steel

Supplies of raw material to British steelworks are adequate and outputs are fully maintained at capacity levels. Steel shipments from the United States continue to arrive regularly, and all the imported material is readily marketed, although the Iron and Steel Control is careful to allocate these more expensive supplies among priority consumers. In order to provide against any emergency which might arise, the Control is retaining a certain proportion of the American steel in stock. There has been a noticeable reduction in the call from certain classes of users, such as structural engineers, but, on the whole, demand is as keen as ever.

Scrap

Reports from consuming centres indicate a rising tendency in the demand for iron and steel scrap. The supply position, however, is sound and merchants are able to satisfy orders without delay. In fact, the supply of many descriptions is greatly in excess of the demand, though this does not apply in the case of certain special qualities. Foundrymen are particularly well placed, and have no difficulty in procuring all the scrap they need. The national survey undertaken by the Iron and Steel Control to record and classify all available fixed and demolition scrap iron is now being concentrated on the Midlands. Scotland, London, Glamorgan and Somerset and all the northern counties of England have been surveyed, and in each case the results have been very encouraging.

Metals

It would appear that Japanese attempts to secure supplies of American copper will meet with even less success in the future than has been the case of late, as recently Mr. Roosevelt issued a proclamation placing copper, together with brass, bronze, zinc, nickel and potash, under the export licensing control scheme, effective as from February 23 next. Since this announcement was made, Japan has made strenuous efforts to purchase copper for prompt delivery, but it is known that United States sellers have rebuffed these attempts to escape the new licensing arrangements. The attitude of American suppliers towards business with Japan has been made quite clear of late, the selling price stipulated in contracts negotiated with Japanese buyers being 12.50 cents per lb., f.a.s., as against a general export quotation of around 10.25 cents. An interesting American copper deal recently has been the purchase by Brazil of 1,100 tons; conjecture exists as to the use to which Brazil will put this tonnage. Strict control continues to be exercised over copper distribution in the United Kingdom, the bulk of the available supply being required for meeting Government contracts.

The British Government is to purchase 126,000 metric tons of copper from the Belgian Congo under financial and economic agreements between the British and Belgian Governments, which were announced on Tuesday in a Foreign Office communiqué.

The day-to-day trend on the London tin market continues to call for little comment; prices are exceptionally steady, and, in the circumstances, dealers find small incentive to operate in the normal way. The American Metals Reserve Company continues to make purchases at its fixed price of 50 cents per lb., c.i.f., but it is doubtful whether export licences in the United Kingdom will be issued with any real freedom, although some relaxation may be expected in this respect, as stocks are at a healthy level (5,000 tons). Nevertheless, the country is in the throes of a struggle with a powerful enemy, and resources have to be watched. The dissipation of our tin stocks at a time when supplies of ores may be adversely affected would be a grave error and is not likely to be made by the authorities.

It has been announced that the Australian Commonwealth Prices Commissioner has fixed the maximum price of minimum 70-lb. tin ingots at £306 per ton at smelters' works.

The visit of a British trade mission to La Paz is reported to have resulted in a financial agreement between the Bolivian and British Governments. No official announcement has been made as to the details of the agreement, but it is believed that a provision for payment in gold to the extent of 75 per cent. and the balance in blocked pounds for the tin shipments to the United Kingdom was included. Proposals to increase Bolivian imports from Britain in exchange for British purchases of antimony, wolfram and tin were considered by the respective parties. Bolivia asked for lists of British general merchandise, particularly machine tools, which might be of use to her.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Thursday, £256 15s. to £257; Friday, £257 10s. to £257 15s.; Monday, £257 5s. to £257 15s.; Tuesday, £257 5s. to £257 15s.; Wednesday, £256 5s. to £256 10s.

Three Months—Thursday, £259 to £259 5s.; Friday, £258 15s. to £259; Monday, £258 10s. to £258 15s.; Tuesday, £258 10s. to £258 15s.; Wednesday, £257 5s. to £257 10s.

The position of brass scrap was surveyed at a recent meeting of merchants in London, and it was decided again to approach the Ministry of Supply on the question. At the outbreak of war large tonnages of heavy brass scrap were being called for at £41 per ton, whereas to-day only small parcels can be moved, and the quotation is down to £28. At the same time, the price of rods is unchanged. Merchants also expressed dissatisfaction with the higher returning charges made by the refiners.

Melting Losses in the Coreless Induction Furnace

(*Continued from page 59.*)

furnace. The chemical composition of the slag appears to be less the determining factor here than the effect of the high arc temperature on the oxidation of the metals and volatilisation of the metallic oxides produced. The more so since the slag in the induction furnace is not heated directly by the arc, but indirectly through the medium of the molten steel, with the result that the slag is at a lower temperature than in the arc furnace, thus also being less reactive. Alloying elements, which are lost from the charge mainly by volatilisation, give lower loss values in both the basic and acid induction furnace than in the basic arc furnace, *e.g.*, the nickel loss in the basic and acid induction furnaces with 40 per cent. nickel steel was 2.5 per cent., while on remelting in the basic arc furnace the loss was nearly 7 per cent. High-Mn steels can only be melted with a basic lining and by running a basic slag, unless special linings, such as Zr-sand linings, are employed, when the relative Mn losses are about 5 per cent. in the basic arc furnace, as against zero in the basic induction furnace.